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JANUARY, 1916

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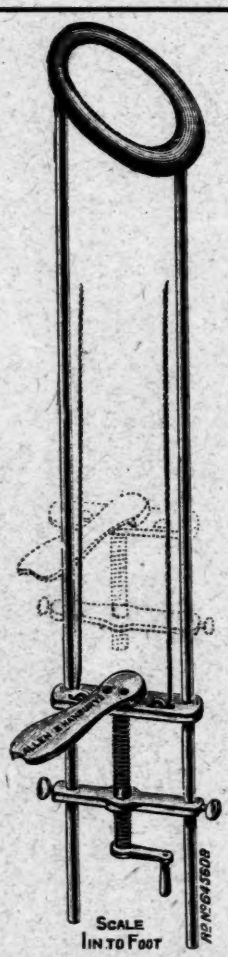
CONTENTS

	PAGE
Richard Wiseman (with Portrait)	349
The Vascular Lesions produced by Gunshot Injuries and their Results — SURG.-GEN. SIR GEO. H. MAKINS	353
Gunshot Wounds of the Shoulder — MAJOR SIR JOHN BLAND-SUTTON	422
The Treatment of Wounds in War — SIR W. WATSON CHEYNE	427
The Bradshaw Lecture on Wounds in War — SURG.-GEN. SIR ANTHONY BOWLBY	451
The Treatment of Penetrating Wounds of the Skull — LIEUT.-COL. PERCY SARGENT AND LIEUT.-COL. GORDON HOLMES	475
Traumatic and Arterio-Venous Aneurysm	
An Aneurysmal Varix of the Internal Jugular Vein and the Internal Carotid Artery, with Unusual Consequences — SIR JOHN BLAND-SUTTON	490
Two Cases from the Wharncliffe War Hospital	492
Note on Arterial Wounds, with Four Cases from the 17th General Hospital — F. C. PYBUS	494
Illustrations of War Surgery — SURG.-GEN. SIR GEO. H. MAKINS AND VARIOUS OFFICERS OF THE R.A.M.C.	497
A Study of Changes in the Leucocytes in Certain Cases of Malignant Disease — O. C. GRUNER	506
Prevention of Deformity following Fracture or Resection of the Jaw: a Plea for the Use of Splints — W. H. DOLAMORE	526
Perforating Wounds of the Rectum — H. J. WARING	549
On the Abuses and Dangers of Drainage Tubes — MAJOR G. GREY TURNER	552
The Surgery of the Enlarged Prostate — GRAHAM SIMPSON	558
Short Notes of Rare or Obscure Cases	
Four Cases of Persisting Infection of the Brain following Injury by Projectiles — C. HAMILTON WHITEFORD	561
Gunshot Perforation of Stomach and Diaphragm — CAPT. V. B. GREEN-ARMYTAGE, I.M.S.	563
Intussusception of the Appendix — GEO. JOHNSON	564
Tamponnade of Perforated Gastric Ulcer — EDRED M. CORNER	566
Appendicitis and Diaphragmatic Pleurisy — EDRED M. CORNER	567
Exophthalmic Goitre and Anoci-Association — EDRED M. CORNER	568
Retroperitoneal Hernia — A. RENDLE SHORT	569
Reviews and Notices of Books	570



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AGE
506
526
549
552
558
561
563
564
566
567
568
569
570

RICHARD WISEMAN.

1622—1676.

FEW men have exercised so wide an influence over British military surgery as Richard Wiseman. Woodall, his immediate predecessor, taught facts in his great work *The Surgeon's Mate*, but Wiseman crystallized his own experience in a series of essays—*The Chirurgicall Treatises*—and generalized in his mature years on the cases he had seen and treated in the course of his active life—a life so active, so hard, and so full of incident that it ended in prolonged illness and death when he should still have been in full practice.

Nothing is known of his birth, parentage, or early education: it is surmised that he may have been an illegitimate son of Sir Richard Wiseman, Bart., of Thundersley Hall, in Essex. He was apprenticed to Richard Smith at the Barber Surgeons' Hall, about January, 1637. At this time he would be some 14 years old, and in seven years, the term of his apprenticeship being over, having attained the age of 21, he entered the Dutch naval service. The Dutch were at war with Spain, and the young surgeon soon saw active service and evidently learnt much, for he says, "In the Armado Naval of Dunkerk, where the Chirurgeons were oft employed, we after every fight went together visiting one another's wounded men. It was thought amongst us a great shame if anything of this work of extraction (of bullets) were then to be done. For after the first and second day the wound proveth tumefied, also the neighbouring parts are inflamed and so changed in their temper that they conceal from your sight both the bullet and his companions, so that the place they are coucht in can hardly be known, or being discerned you cannot without hazard of your patient or great trouble of the part make extraction of them." He taught, therefore, that bullets should be extracted at once "if the wound be near a joint or amongst the tendons; but if it be lodged in a less noble part, as in the musculous flesh," it may be left for a few days; but still it must be removed, "for the bullet pierceth not any part without carrying rags along with it, which corrupt in the wound."

Wiseman was equally sure that primary amputation was the best course to pursue in many cases, but by no means as a routine, for he says, "Consider well the member, and if you have no probable hope of Sanation, cut it off quickly while the soldier is heated and in mettle. But if there be hopes of cure, proceed rationally to a right and methodical healing of such wounds; it being more to your credit to save one member than to cut off many." And in another place, "Amongst the cruisers in private Frigates from Dunkerk it was complained that their Chirurgeons were too active in amputating those fractured members. As in truth there are such silly Brothers, who will brag of the many they have dismembered, and think that way to lie themselves into credit. But they that truly understand Amputation and their Trade well know how villainous a thing it is to glory in such a work." In illustration of this teaching he quotes an interesting case:—

"In heat of fight at Sea, amongst the many wounded men that were put down into the Hold to me, one of them had his right arm extremely shattered

about two fingers' breadth, on the outside above the elbow, by a great splinter. I ought to have cut off this man's arm presently, but a sudden cry that our ship was on fire put me in such disorder that I rather thought of saving myself than dressing my patients. I hastily clapt a dressing upon the wound and rolled it up, leaving his arm in his other hand to support it, and endeavoured to get up out of the hold as the others did, verily believing I should never dress him nor any of them more. But our men bravely quitted them of the Fire-ship by cutting the Sprit-sail-tackle off with their short hatchets (which they wore during fight sticking in their sashes). So we were freed of the fire, and by hoisting up the top-sails got clear of our enemy and I returned to work. But I was at a loss what to do with this man, who lay not far off complaining of his arm. I would have cut it off instantly with a Razor (for the bone being shattered there needed no saw), but the man would not suffer me to meddle with his arm, he crying it was already drest. The fight being over and we gotten into the next Port, I caused this mariner's bed to be set up (which was four pieces of wood nailed together and corded and a Bear's skin laid upon it), and fastened between two guns to the carriages." Wiseman then put the arm into splints; laying the patient's arm on a cushion and the hand on the chest, he put his fingers into the wound and pulled out a large fragment of bone, "with rags and bones, great and small, so that I left not the least shiver. My patient was easier than any of my other with fractured wounds. When it came to my turn to be visited by my Brother Chirurgeons of our Squadron, they did not dislike the wound nor my way of dressing (for we being used to see one another's patients had all much one way of dressing). But they laughed at the excuse I made for not cutting off his arm, and doubted I should yet be forced to do it." However, in the end "this patient had a strong callus filling up the void place of the lost bone at least two inches, with little or no shortening of the arm; but the joint of the elbow was so stiff from the position it lay so long in, that he could not stretch the joint whilst I knew him, which was until that ship was cast away."

How long Wiseman was employed in the Dutch navy is not known, but in 1645 he was in England during the Civil War, serving with the Royalist troops in the West, and was present at the siege of Weymouth, at the rout at Truro, and at Taunton, where he was called upon to treat a man who was shot in the face by a case-shot which carried away his eyes, nose, mouth, and forepart of the jaws with the chin. "I bound his wounds up, and we left that deplorable creature alive six or seven days later."

After the rout at Truro he was in personal attendance upon Prince Charles (afterwards Charles II), and accompanied his master to Jersey, France, Holland, and Scotland, until at the battle of Worcester he was taken prisoner and marched to Chester.

In February, 1651–2, he was allowed to come to London, where he was at once admitted to the freedom of the United Company of Barbers and Surgeons, and thus qualified himself to practise in the city. He acted for a time as assistant to Edward Molines of St. Thomas's Hospital, but soon settled at the King's Head in the Old Bailey, where he gained considerable practice through his royalist friends.

Early in 1654 he was arrested on a charge of conniving at the escape of one of his patients from the Tower, and was imprisoned in Lambeth Palace.

RICHARD WISEMAN

From a Miniature in the possession of His Grace the Duke of Rutland

Being released, he served, according to his own account, for three years in the Spanish navy, some part of the time at least being spent in the tropics. Early in 1660 he returned to London and lived again in the Old Bailey; but with the Restoration his prospects improved, and he moved to Covent Garden, then recently built and forming a fashionable outskirt to London. Within ten days of Charles II's return Wiseman was appointed "Surgeon in Ordinary for the person," apparently on the direct nomination of the king. In 1672 he was promoted principal surgeon and serjeant surgeon. His court appointment made his promotion at the Barber Surgeons' Company easy and rapid; he was chosen a member of the Court of Assistants in 1664, and in the following year was elected Master of the Company, although he had not filled the usual offices of Warden.

Wiseman died suddenly at Bath, and was buried in the Church of St. Paul, Covent Garden, on August 29, 1676. He bore for arms, which were granted him, says Dr. Clippingdale, on April 24, 1671: Sable; on a chevron between three busses of a lance, a trefoil slipped of the field; and for augmentation: on a canton or, a rose gules. Crest: A seahorse proper resting the dexter paw on an escutcheon or, charged with a rose gules." These arms, as Dr. Clippingdale points out, are very similar to those borne by Sir Robert Wiseman, Vicar General and Dean of Arches, and they present no heraldic symbol of bastardy; whilst the trefoil of shamrock added to Richard Wiseman's coat may indicate that his mother was a lady of Irish birth.

Wiseman was twice married. His first wife died on Feb. 23, 1674. His second wife—a daughter of Richard Mauleverer, and granddaughter of Sir Thomas Mauleverer, the regicide—survived him, bore a posthumous son who was buried in 1678, and married Thomas Harrison the lawyer, who settled the affairs of her first husband.

We have some record of Wiseman's personal appearance, for two portraits of him are in existence. One is a miniature at Belvoir Castle, in the possession of His Grace the Duke of Rutland. It is dated 1660, when Wiseman was about 37, and represents him as an apparently healthy man, with long hair, rich clothing, a deep collar, and lace cravat. The face is thoughtful, with a large mouth, thick lips, and wide nostrils. The second portrait hangs in the council room of the Royal College of Surgeons of England, and was painted by Sir Balthazar Gerbier. The artist died in 1667, so that it must have been painted within a few years of the miniature. It shows Wiseman refined by illness, with delicate features, and the aspect of a scholar rather than a man of affairs. He was already a prey to that illness to which we are indebted for the *Chirurgicall Treatises*, for he says of them, "I have made a virtue of necessity, and employed those hours for the public service which a frequently repeated sickness hath for these twenty years last past denied me the use of in my private occasions. It hath pleased God by casting me into such a condition to give me opportunity of reading and thinking." Of the nature of this illness there is little doubt, for he says, in recording a case of trephining for a punctured fracture of the skull, "Going presently out of his close room (where I was crowded up with great lights burning near me) into the fresh air, I presently burst out with a violent coughing of blood, yet the next day I dressed the patient again, and found his speech and limbs restored; but he was hot and his pulse quick."

Physically, and upon his own confession, Wiseman was no braver than Socrates is said to have been, for he ran away when he could do so conveniently. Thus, at Truro, "At the beating of some of our Out-Guards, the enemy pursuing them, a Trooper wounded between the right brow and ear, espying me amongst the crowd importuned me earnestly to dress him and would admit of no excuse. We stopt at an Apothecary's house on the right hand going out of the town towards Perin. I called to the Apothecary's servant to bring somewhat to dress him. Meanwhile I hastily lifted up the bloody hair and saw a quantity of the brain lie among it. I took it up with my fingers and showed it him; the sight whereof so calmed his passion that I had liberty to fly from the enemy who was entered into the town." In like manner, at the Battle of Worcester, "A soldier came to us where we were dressing, with his sword in his hand, the blade broken off near the hilt, with many wounds in his head. I seeing the hairy scalp of one side of his head hanging down his neck, went to him and calling my friend Will. Clarke to me with a sponge to cleanse the wound, we saw six pieces of the skull sticking on it. We freed the scalp of those bones and returned it upwards. The alarm growing hot of the Enemies entering the City, I left Will. Clarke to bind it up and made my way out of the town. But this young Chirurgeon being taken, busied in the dressing of wounded soldiers, had liberty after the heat of the fight was over to employ his charity in dressing some of them."

The *Several Chirurgicall Treatises* are eight in number. They treat of Tumours; of Ulcers; of the diseases of the Anus; of the King's Evil; of Wounds; of Gunshot Wounds; of Fractures and Luxations; and of the Lues Venerea. All are written in such pure English that it is a pleasant literary exercise to read them for their style alone. Wiseman treats of the cause, symptoms, prognosis, and cure of the different conditions, and then illustrates his remarks with the details of cases which he has himself seen and treated. He records his successes and failures quite impartially, for, as he well says, "I have done it faithfully and thought it no disgrace to let the world see where I failed of success, that those that come after me may learn what to avoid; there being more of instructiveness often in an unfortunate case than in a fortunate one; and more ingenuity in confessing such misfortunes, which are incident to mankind and which have attended all my brethren as well as myself, and will attend thee also, Reader, in spite of all thy care and diligence, if thou undertake the employment. Thou wilt also learn one necessary piece of Humility, viz. not to trust too much on thy own judgement, especially in difficult cases, but to think fit to seek the advice of other Physicians and Chirurgeons, whose long experience hath enabled them to assist thee in preventing the accidents and encourage thee to go on in the work or forewarn thee of the danger. After thou hast thus defended thyself from the censure of rashness, proceed boldly and let thy sincerity in thy acting be thy warrant to hope for God's blessing on thy endeavours."

Wiseman, it will thus be seen, was both honest and a gentleman. He was on friendly terms with the physicians of the day, a fact in itself remarkable when surgery was essentially a trade; indeed it was Wiseman's example that gave an early impetus to that desire for a separation of the surgeon from the barber which ended in the formation of the Surgeons' Company in 1745.

ON THE VASCULAR LESIONS PRODUCED BY GUNSHOT INJURIES AND THEIR RESULTS.

By Surgeon-General SIR GEORGE H. MAKINS, K.C.M.G., C.B.,

Consulting Surgeon to the Forces.

This communication must be prefaced by the remark that the writer fully appreciates the fact that it deals solely with a certain stage of progress of the lesions described. The circumstances of the present campaign, which necessitate the rapid evacuation of all patients able to bear transference to England, have prevented not only the opportunity for treatment, but also of prolonged observation. None the less, the material dealt with provides many points of interest for consideration; and if its publication had been further delayed, at least another twelve months must have been allowed to elapse before any reliable permanent results were ready for observation and review. Such results, moreover, may well form a part of a more extensive report when the campaign is ended.

The present war has afforded some surprises with regard to gunshot injuries inflicted upon the blood-vessels. Primarily it was expected that the experience gained in the South African and succeeding wars would be merely confirmed; but one of the first observations made was to the effect that *isolated* injuries either to the vessels or the great nerve cords were vastly less frequent than was the case during the period in which the dome or ogival tipped bullets were in use. It became at once apparent that the instability of flight of the sharply pointed bullet, unless the latter strikes the body at an exact right angle to the surface, is opposed to the production of neat and limited perforations such as were common with the better balanced earlier forms, and that the injuries to the blood-vessels as a class are not only more severe in themselves, but also accompanied by more extensive destruction of the surrounding soft tissues.

Later experience of the common use of the high explosive shell, and especially of the various forms of bomb (all of which furnish a large number of small, sharp, ragged fragments), has shown also that these missiles are as frequently the cause of vascular injuries, resulting in one of the various forms of traumatic aneurysm, as rifle bullets, although the wounds are of a somewhat different character. The increased number of wounds caused by missiles of this class has in fact greatly multiplied the number of traumatic aneurysms met with amongst the wounded.

Of some interest, though of less common occurrence, are the vascular injuries produced by the shrapnel ball, since these are practically identical with those caused by the old round ball of 'Brown Bess' (*Fig.* 120). An aneurysm resulting from a bayonet wound has not yet come under my observation.

FIG. 120.—LATERAL WOUND OF THE COMMON CAROTID ARTERY, AND COMPLETE SEVERANCE OF THE INTERNAL JUGULAR VEIN.

The vein is thrombosed, and the opening in the artery partially closed by fibrinous clot. The patient died of secondary hæmorrhage on the twenty-fourth day.

This illustration is inserted for purposes of comparison. The specimen from which it has been drawn came from the Peninsular War, and it is interesting to note that the injury caused by the old round ball differs but little from those produced by the modern rifle bullet. The dilatation of the contused trunk in the neighbourhood of the wound is a rather striking feature. (*Museum Royal Army Medical College, No.* 34·2.)

PART I.

CONTUSIONS OF THE BLOOD-VESSELS.

Before proceeding to the consideration of the actual perforating injuries of the blood-vessels, some attention needs to be bestowed upon the contusions and incomplete lesions of their walls.

Arterial Thrombosis.—The fact that primary arterial hæmorrhage is so frequently and efficiently controlled by the rapid formation of a firm thrombus, is undoubtedly referable to the contused nature of the injury to the vessel wall in gunshot wounds.

Arterial thrombosis is also far from uncommon when the passing missile fails to produce a perforating lesion, merely contusing the vessel or carrying away a part of the external coat. It has been shown experimentally that ruptures of the intima and muscularis may be produced by contusion of the vessel, though the formation of extensive thrombi has not, I believe, been observed under aseptic conditions. During the present campaign, arterial thrombosis from this latter cause has been a fairly common occurrence, as the result both of limited and extensive contusions of the walls of the vessels. The process has been observed in the case of apparently clean, uninfected bullet tracks, and also in extensive septic wounds in the immediate neighbourhood of the vessels (*Fig.* 121.)

FIG. 121.—INJURED POPLITEAL ARTERY AND VEIN, FOLLOWED BY GANGRENE OF THE LEG (*Case* 91).

The vein has suffered complete severence as a result of the passage of the bullet. The ragged, frayed ends of the vein are well shown. The amount of separation of the ends is less than the average distance, a fact readily explained by the firm nature of the connection normal to this particular artery and vein. The lower end of the vein is still occupied by a thrombus.

The artery, which has suffered a severe contusion, presents a fusiform enlargement occupied by a thrombus opposite the gap between the ends of the severed vein. Both above and below the thrombosed spot the calibre of the vessel is notably diminished, a condition usually seen when the normal arterial circulation is arrested either by a thrombus or a large wound involving the lumen (Under the care of CAPT. W. G. MUMFORD, No. 13 General Hospital, Boulogne.)

In certain positions, and in the case of wounds which heal with no clinical evidence of infection, it is often extremely difficult or actually impossible to determine whether the lesion consists in mere contusion or complete solution of continuity of the vessel. This is notably the case in tracks traversing the root of the neck. With these injuries, complete disappearance of the pulses at the wrist, not infrequently associated with a brachial monoplegia of a more

or less complete degree, is not at all uncommon. When, under these circumstances, no systolic bruit is present at the supposed site of injury, and no aneurysmal swelling develops at a later date, we are absolutely unable to decide whether we have a case of contusion, or one of complete division of the artery to deal with. On the one hand we are aware that a contusion may account for the symptoms, on the other that a complete division of the vessels may be accompanied by identical signs. (See *Case* 104, operated upon by Colonel Gordon Watson.)

Thrombosis in connection with incomplete lesions of the vessel wall may be limited in extent—either not completely obstructing the flow of blood, or only doing so temporarily—or it may be very extensive. The latter condition is met with mainly, if not solely, in connection with extensive septic wounds, and has long been familiar to the military surgeon (*vide* a specimen of femoral thrombosis sent home by Mr. Guthrie from the Crimean War, preserved in the museum of the R.A.M. College). These thrombi may extend over some inches of the artery, and may occasion primary gangrene of the limb; may be followed by the occurrence of secondary hæmorrhage; or may afford an origin for emboli, which, becoming arrested in the peripheral circulation, may lead to gangrene or nutritional disturbance at a later date. In the last particular the limited thrombi are of the greatest interest.

FIG. 122.—CONTUSION OF THE BRACHIAL ARTERY, WITH INCOMPLETE LACERATION OF THE WALLS OF THE VESSEL (*Case* 94).

The adventitia is ruptured, the muscularis almost intact, and the intima broken. Over the damaged portion of the intima a local lateral thrombus has developed. The importance of this specimen, taken in connection with the cases of probable contusion of the carotid arteries followed by cerebral embolism, is obvious. *a*. External aspect. *b*. Internal aspect. (Under the care of LIEUT. LLEWELLYN, No. 25, General Hospital, Camiers.)

It is not easy to decide how often incomplete lesions of the walls of the arteries eventually lead to the development of secondary aneurysm; but in the light of their obvious importance as a source of secondary hæmorrhages, it appears highly probable that the origin of some aneurysms detected at a comparatively late date may be attributed rightly to such primary injuries. Moreover, actual dilatation of large arteries has been observed to occur as an early result of an incomplete lesion.

Secondary hæmorrhage from vessels the seat of incomplete lesions is most commonly met with in the case of arteries exposed in septic wounds, and may occur comparatively early as a result of disintegration of the infected thrombi. It is even more likely to occur than when complete severance of the vessel has been effected, since in the latter event the ends of the vessel have retracted, and the thrombus, as more deeply situated, stands a better chance of escaping infection.

Primary gangrene, especially in the lower extremity, is not uncommon. This might be expected, because the obstruction to the lumen of the vessel is often much more extensive, and hence more liable to involve the origin of important collateral branches, than is the case when the vessel is completely severed.

Thrombosis as a consequence of contusion is more commonly seen in the veins than in the arteries, and in connection with a much slighter degree of damage to the walls of the vessels. I have seen it on several occasions when ligaturing an artery which had suffered a lateral wound. The latter observation is important in its bearing on the question of the danger of simultaneous occlusion of both main artery and vein resulting in gangrene of the limb. I am more and more disinclined to believe that the co-existing localized thrombosis of the vein in any way endangers the vitality of the limb should the artery need to be tied. In fact, from a considerable amount of experience, I am not sure that the balance of the normal circulation is not afterwards better maintained. At the same time, I must allow that a local thrombosis at the point of injury sometimes favours the development of an extensive peripheral thrombosis, for I have seen it on more than one occasion, yet not giving rise to gangrene.

Arterial Embolism.—The most interesting and often the most serious sequence of arterial thrombosis is the detachment of emboli from lateral thrombi of insufficient size to occlude the vessel, or from those which only temporarily occlude the vessel. This accident must, I think, be considered entirely apart from the cases in which the detachment of the embolus is a direct consequence of septic infection and disintegration of the thrombus. It is a question of considerable importance, because it has been stated that the process does not take place in the absence of infection.

The evidence that I have to offer of the occurrence of such embolisms depends mainly on clinical observation; unfortunately one of the patients in whom it was observed died in the hospitals abroad, and in him no autopsy was made.

Fig. 122, however, affords absolute proof of the occurrence of lateral thrombosis as a result of a non-perforating lesion of an artery.

The specimen was obtained by Lieut. T. L. Llewellyn under the following circumstances. A man giving instruction at a bombing school was wounded by the premature explosion of the bomb. A fragment of the bomb-casing entered on the inner aspect of the arm, and lodged beneath the skin of the outer side, the track of the missile crossing the course of the brachial artery one inch below the insertion of the deltoid. The fragment of shell was removed at the casualty clearing station and the patient was sent down to the base.

On admission, it was noted that the radial artery at the wrist was barely pulsating. As an injury to the brachial artery was suspected, the vessel was exposed and found to have been contused by the missile. The bruised spot felt hard, and appeared to be occupied by clot, but pulsation was present in the vessel both above and below the obstruction. Ligatures were placed above and below the injured portion, which was excised. The distal tied end pulsated visibly. The patient made an uninterrupted recovery, pulsation in the radial artery at the wrist being strong a week later.

The occurrence of arterial embolism as a sequence of contusion is best illustrated by the relation of some cases in which it was observed.

Case 87.—(Under the care of LIEUT.-COL. GORDON HOLMES.)
A man was admitted four days after the reception of a small slit-like wound situated at the anterior border of the left sternomastoid, one inch below the angle of the mandible. The man had lain two days in the trenches after receiving the wound, and when removed he was unconscious and hemiplegic. When examined at the base, a small circular induration was present over the upper part of the left carotid artery, but pulsation in the vessel above that spot and in the left temporal artery was not reduced in strength or volume, and no bruit was present at the site of the lesion. The heart sounds were normal.

The patient remained in the hospital for fourteen days, during which time he improved somewhat; there was little change in the hemiplegia, but speech was regained although reading was difficult; the capability of writing returned, and the mental condition steadily brightened. He was transferred to England in this condition.

Case 86.—(Under the care of CAPT. WOLFENDEN.)
A man was wounded by a bullet which entered the anterior border of the right sternomastoid muscle an inch above the sternum. The bullet was retained over the spines of the 6th and 7th dorsal vertebræ. There was complete paralysis of both lower extremities, and incontinence of urine and fæces. Besides the spinal lesion, complete loss of power was present in the left upper extremity, and the man was dull and stupid. Pulsation in the right carotid artery was normal, no bruit was present, and no abnormal sounds could be detected on auscultation of the cardiac area.

No improvement occurred, and the man was transferred to England.

In connection with the above two cases of embolism following contusion of the artery, it may be convenient to insert the following ones, illustrating the occurrence of similar phenomena where the vessel, although wounded, still remained patent, and capable of carrying on the circulation satisfactorily prior to the detachment of an embolus.

In the section dealing with carotid aneurysms, an example of an embolus becoming detached from the sac during the process of cure will also be found (*Case* 2).

Case 16.—(Under the care of LIEUT.-COL. BUTLER.)
A man was wounded by a bullet which entered in the left posterior triangle and emerged near the angle of the left scapula. He remained in the trenches three days after reception of the injury. A large hæmothorax was present on the patient's admission, and an arterial bruit was audible over the left subclavian artery. A left brachial monoplegia was present. Two days later the left hand was noted to be cold and blue, and no pulsation could be felt in the vessels below the bifurcation of the brachial. The hand became gangrenous, and was amputated a week later. The hæmothorax suppurated and was drained; but the man did well, and no sign of any aneurysm developed locally.

Case 12.—(Under the care of MAJOR DAVIES-COLLEY.)
A man with a small, slit-like wound at the anterior margin of the left sternomastoid, at the level of the angle of the mandible, was admitted without any previous history, but completely aphasic. There was no further paralysis, but the left palpebral fissure was small, and the right pupil was larger than the left. An arterio-venous aneurysm with a double murmur and thrill was present, pulsation being palpable both from without and on palpating the tonsil. No improvement occurred, and the man was apparently unable to comprehend remarks addressed to him. He was transferred to England at the end of fourteen days.

Cases of embolism in connection with the disintegration of septic thrombi are included in the tables at the end of the paper.

NATURE OF THE WOUNDS OF THE VESSELS.

Regarding the anatomical characters of the wounds produced by the rifle bullet, there is little to be added to what is already known. The wound itself is of a contused nature, the margins being tattered and irregular in the recent state, later becoming rounded and smooth during the process of repair or the formation of an aneurysm. The characters are sufficiently illustrated in the figures and accompanying legends.

The introduction of the unstable pointed bullet has, however, considerably varied the proportional occurrence of the different forms of wound. Complete severance of continuity, or wounds involving the greater part of the circumference of the vessel, have become more frequent, while perforations involving both sides of the lumen of the vessel have become rare. A difference in this respect between arteries and veins has been conspicuous amongst the cases which have come under my own observation, as transfixion of the vein has been met with several times in association with a lateral wound of the artery (see *Figs.* 126 and 130). I have only seen three cases of perforation of an artery—the popliteal in one instance (see *Fig.* 140), the femoral in the adductor canal in a second, and the brachial in a third. The femoral perforation was ragged, and apparently larger in diameter than the base of the bullet which produced it; when exposed from Hunter's canal, the clot which occupied the popliteal space could be squeezed across the vessel through the two perforations by pressure upon the surface of the limb.

Wounds produced by fragments of shells or bombs differ somewhat in character, more nearly resembling the incised variety, sometimes being little more than minute punctures (see *Figs.* 123 and 124).

A word may be added as to the anatomical characters of the wounds of the veins. The liability to perforation has already been referred to. When completely divided, the appearance of having been torn through is very marked, the margins are often much frayed (see *Fig.* 121), and the tendency to retraction is strong. The common result is the formation of an occluding local thrombus, naturally more constant in the central end of the divided vessel. I have frequently seen free hæmorrhage from the distal end, when the central is completely closed. The occurrence of thrombosis is obviously of great moment in regard to the conditions favouring or otherwise the formation of an aneurysm of the arterial or arterio-venous variety respectively.

If sufficient time has elapsed to allow of repair, the mouth of the completely divided vein may, under certain anatomical conditions, be spread out as a trumpet-shaped opening in the aneurysmal sac. In one instance where the junction of the subclavian and first part of the axillary vein (*Case* 21) had been divided, the two ends, which opened into an aneurysmal sac, were separated by a distance of two and a half inches, while the upper opening, which had acquired connections to the clavicle and first rib, was of sufficient calibre to allow the introduction of the tip of the index finger. Needless to say, very free hæmorrhage occurred when the sac was laid open, and was with great difficulty controlled. The experience is one to be especially kept in mind if an aneurysm in this region requires to be dealt with. *Fig.* 127 shows well the different characters of arterial and venous wounds, that in the more resistant

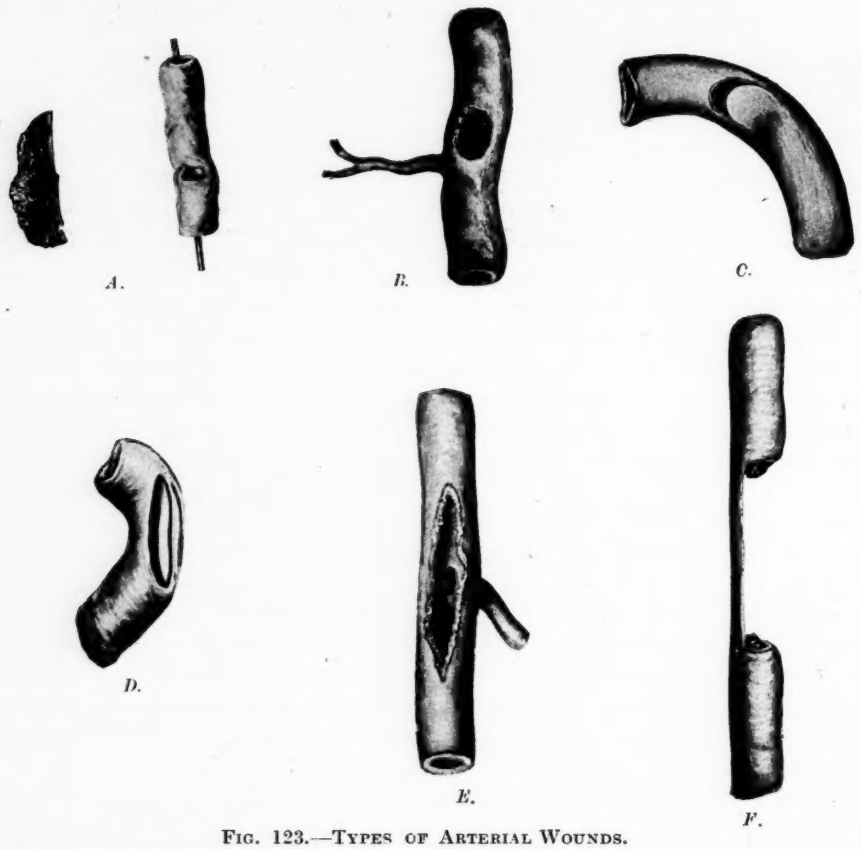


FIG. 123.—TYPES OF ARTERIAL WOUNDS.

A. Small portion of the femoral artery (*Case* 51) removed at the time that the aneurysm was extirpated and the vessel ligatured, with the piece of shell which produced the injury. The regular outline and smooth margins of such an incised wound at the end of ten days is well shown. A typical soft musical bruit was present before the operation. (Under the care of CAPT. WOLFENDEN, No. 11 General Hospital, Boulogne.)

B. Oval wound of superficial femoral artery (*Case* 39). The wound is in immediate proximity to a lateral branch fixing the artery. Shell injury. (Under the care of CAPT. STANLEY RAW.)

C. Diagrammatic representation of a flap-like wound of subclavian artery (*Case* 18). Large mass of primary clot; no aneurysmal sac formed; secondary cellulitis of neck; secondary hæmorrhage. Shell injury. (Under the care of LIEUT.-COL. GORDON WATSON.)

D. Oval wound of superficial femoral artery (*Case* 40). The thin strip of arterial wall between the main opening and the lateral slit shows this to have been actually a perforation. Secondary hæmorrhage appears to have taken place through the lateral slit. The specimen has become bent during the process of preparation. Bullet injury. (Under the care of LIEUT.-COL. GORDON WATSON.)

E. Unusually long lateral wound of axillary artery. Note the branch arising immediately opposite the centre of the wound. (Under the care of LIEUT.-COL. ELLERY.)

F. Diagrammatic representation of a three-fifths division of the femoral artery. This form is frequent, and amounts practically to a complete division of the vessel. It is, however, a more serious injury, since the remaining bond of union prevents free retraction and contraction of the ends, and hence spontaneous thrombosis and closure of the vessel is less likely to take place. Bullet injury.

It will be noted that all these vessels were exposed from three to ten days after the infliction of the wound, hence the margins of all are more even and rounded than in the recent stage of the injuries. No typical example of double perforation is included, because no opportunity has occurred for the removal of such a wound.

and brittle arterial wall being a simple transverse cleft, while the opening in the vein caused by contact of the same bullet is irregular in outline and roughly stellate in character, with small flaps.

EFFECTS OF GUNSHOT WOUNDS OF THE BLOOD-VESSELS.

Primary Hæmorrhage.—Little needs to be said on this subject: recent experience appears to fully confirm the ancient opinion that spontaneous cessation of bleeding is a common result in all except the largest vessels of the trunk. In type bullet wounds the almost invariable history given by the wounded men is one of a primary spurt of blood, often abundant, but readily controlled by local pressure and the application of a dressing. It is not a common event in the case of small wounds of the soft parts for recurrent hæmorrhage to take place when the dressings are renewed. In large, open wounds, vessels of the calibre of the brachial or femoral arteries are frequently met with completely divided, but occluded by a firm efficient thrombus, and the latter is usually not displaced by the manipulation necessary for the cleansing of the wound. In such cases the calibre of the vessel is commonly greatly reduced, and this reduction in size becomes a permanent change.

It must not be assumed that the above remarks concerning the common spontaneous cessation of primary hæmorrhage from arterial wounds is intended in any way to minimize the importance of what does occur. The loss of blood which accompanies the receipt of the injury is often very considerable; and although it may not immediately endanger the patient's life seriously, or call for surgical intervention to prevent its recurrence, yet the resulting anæmia is often persistent for some time, and may heavily handicap the patient's chances should a secondary operation become necessary. It has, indeed, much surprised me to see patients die a few hours after an operation in which, although a considerable amount of blood has been lost during the procedure, yet the patient has left the table in sufficiently good condition for no great anxiety to have been felt regarding his ultimate recovery. I believe this to be a definite sequence of the primary loss of blood, and it is a moment to be fully considered should the question of the performance of any operation likely to entail loss of blood arise.

Again, the absence from this series of aneurysms of the great vessels of the trunk, sufficiently emphasizes the fatal nature of wounds of the larger arteries.

Secondary Hæmorrhage, apart from that occurring in connection with arterial hæmatomata, is so large a subject as to be outside the scope of this paper; in addition, the most serious and common secondary hæmorrhages occur from the smaller vessels, are dependent solely on the presence of sepsis, and hence cannot be regarded as due to the special form of wound. Some remarks on secondary hæmorrhage in special cases are made in the sections on the treatment of wounds of individual arteries.

ARTERIAL HÆMATOMA AND FALSE ANEURYSM.

Apart from external hæmorrhage, the most common sequence of a gunshot wound of a large vessel is the development of an arterial hæmatoma, usually a large pulsating collection of blood lying at first in the tissues, its

line of extension being dependent on the anatomical arrangement of the part concerned. The most characteristic are those which develop in connection with comparatively superficial vessels such as the common femoral or the third part of the subclavian. In these the hæmatoma is commonly accompanied by widespread ecchymosis of the overlying integument. When the deeper vessels are wounded ecchymosis is rare, the soft fluctuating local swelling is replaced by a tense general swelling of the limb, and no definite limitation of the extent of the cavity can be determined.

The first secondary change consists in coagulation of the effused blood at the circumferential part of the cavity, which process tends to check primarily any further extension of the extravasation. As the process of coagulation

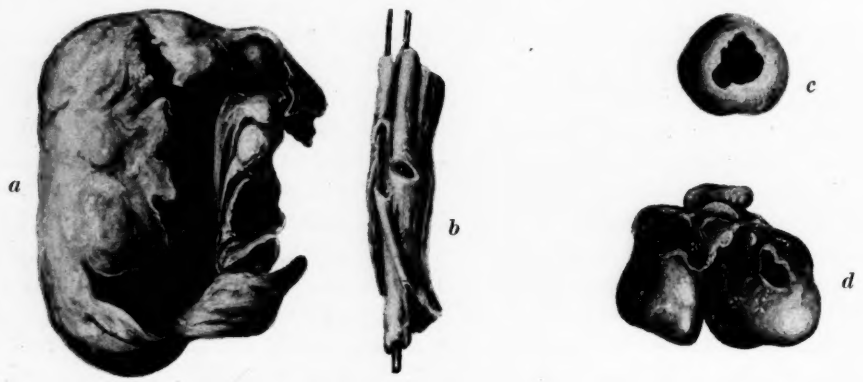


FIG. 124.—THREE SMALL FALSE ANEURYSMAL SACS DEVELOPED IN CONNECTION WITH WOUNDS OF THE POSTERIOR TIBIAL ARTERY.

The largest and most irregular (*a*) has beside it the artery (*b*) showing a small lateral wound and one of the venæ comites also wounded. The patient from whom it was removed had a compound fracture of the leg, the wound accompanying which was badly infected. Pulsation and a purely arterial bruit were not noted until the tenth day. On the fifteenth day secondary hæmorrhage occurred, and the limb was amputated (*Case* 83). (Under the care of LIEUT.-COL. BUTLER, No. 13 Stationary Hospital.)

The smallest sac (*c*) is fairly symmetrically globular; the hole by which the wound in the artery communicated with it is well shown, also the tenuous nature of its margins. A magnified section of the wall of this sac is seen in *Fig.* 125 (*Case* 84). (Under the care of CAPT. CLEMENTI SMITH, No. 13 General Hospital, Boulogne.)

The third sac (*d*) resembles the two others in character; the small hole communicating with the lumen of the artery is seen. The whole structure is somewhat tripartite in outline, but the two secondary masses contain only a small cavity, and consist mainly of solid clot. (Under the care of CAPT. W. G. MUMFORD, No. 13 General Hospital, Boulogne.)

proceeds, shrinkage of the resulting clot takes place, with the result of producing a definitely localized, pulsating swelling which may project boldly from the surface of the part of the body affected. The extent to which coagulation may proceed varies; in a minor proportion of the cases the central portion of the effusion remains fluid in direct continuity with the contents of the wounded artery, and the condition of arterial hæmatoma persists for some time. This class of case is that most liable to suffer from the effects of infection of the surrounding tissues, which may result in secondary extension, or external secondary hæmorrhage. It is most frequently met with in situations such as Scarpa's triangle, in which the blood effusion is afforded but slight support by the surrounding structures.

In other instances, particularly in the case of vessels well supported by the surrounding structures, the entire effusion may become metamorphosed into a firm clot, and the primary systolic bruit produced by the wound in the artery may disappear completely. If a primary bruit disappears, we may assume a limited lateral wound of the artery to be present. The further progress of such cases varies; the large hard clot is a primary cause of danger, since it tends to exert very firm pressure on the collateral vessels, and hence gangrene of the peripheral part of the limb is apt to occur, especially if the femoral or the popliteal artery has been wounded.

A more common result is the secondary development of a false aneurysmal cavity. The impact of the blood-stream opposite the defect in the arterial wall tends to hollow out a rounded space in the recently coagulated blood, or to regularize any residual space remaining in the clot. The resulting cavity acquires a boundary formed by the deposition of well-marked layers of laminated clot, resembling that met with in typical spontaneous aneurysms. The sacs when small and recent are readily separable from the surrounding mass of conglomerate primary clot. The wall of the sac is thickest at the point most distal from the arterial wound, becoming gradually thinner as it approaches the opening in the artery, to the edges of which it is united by a comparatively tenuous layer. When laid open, the smooth, shining, inner surface of the sac suggests the presence of an endothelial lining, even at an early stage of development. When this stage has been reached the designation of arterial hæmatoma ceases to be applicable, and the term false aneurysm is preferable, since the old irregular blood cavity is gone and is replaced by a distinctly new formation. In *Fig.* 124, *c* and *d* show examples of two such sacs developed in connection with the posterior tibial artery; both were wiped out of the deep layers of the calf through incisions made to evacuate large masses of clot with which their connection had been severed.

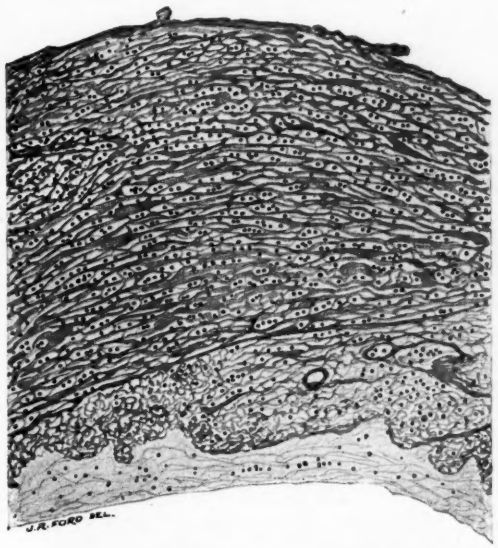


FIG. 125.—A SECTION OF THE WALL OF THE SMALL ANEURYSMAL SAC SHOWN IN *Fig.* 124, *c*. MAGNIFIED TO DEMONSTRATE ITS STRUCTURE ($\frac{2}{3}$ *objective*).

The wall is formed by interlaced concentric laminæ of fibrin and, within the meshes of the network, blood-corpuscles. No fibrous tissue has yet been developed.

In the case of larger vessels, when hæmorrhage necessitates an early operation similar cavities are found in the clot and in connection with the open wound in the artery; but they may be still incomplete, the laminated clot and smooth surface being more dome-shaped, and hardly extending to the actual lips of the arterial wound.

I believe this process occurs whenever a false aneurysmal sac is really

developed, since such cavities, whenever they have existed for a short period, are roughly or symmetrically spherical in form, while the original space occupied by the arterial hæmatoma is usually extremely irregular. The subclavian aneurysm depicted in *Fig.* 132 is a good example, the original collection of blood having occupied the whole posterior triangle of the neck. Again, when the femoral artery is wounded by a bullet traversing Hunter's canal, the original blood effusion travels into the posterior compartment of the thigh through the opening in the adductor muscles. Yet the cavity of a traumatic aneurysm developed in this position is in my experience almost invariably a rounded sac limited to the anterior aspect of the adductor muscles, and not an hour-glass sac extending from the front to the back of the limb. The great mass of primary blood-clot is in fact quite independent of the eventual aneurysm.

In some instances the original large common space occupied by the hæmatoma becomes loculated, and the circumferential part may become cut off. This was the case in the subclavian aneurysm depicted in *Fig.* 132, p. 386. The fluid contained in the superficial loculus in the posterior triangle had already become decolorized at the time of operation, and was quite independent of the deeper aneurysmal cavity beneath the remains of the scalenus anticus. In this case the loculus was a development of much importance, since the thinning of its walls, with the consequent apparent increase in size in the swelling to which pulsation continued to be communicated, was regarded as indicating the necessity for operation.

Behaviour of Surrounding Tissues.—It must not be assumed that the processes of diminution of size and solidification of the walls of the aneurysmal sac depend solely on the absorption and contraction of the primary clot, the hollowing out of the interior, and the deposition of fibrinous laminæ capable of later development into fibrous tissue. Nor do these things alone ensure the limitation and final solidity of the aneurysm. A not less important part is played by the surrounding tissues, which appear to react in a remarkable manner to the stimulus afforded by the presence of the blood-clot in their midst. The connective tissue of the vascular cleft, the intermuscular spaces, and the muscles themselves, become infiltrated with serum and an abundance of leucocytes destined to take part in the subsequent absorption of the clot.

A considerable part of the mass of the tumour in the early stages consists of this surrounding infiltration, and the gradual disappearance of the latter and of the œdema accounts for much of the diminution of the apparent size of the tumour. It is this induration which affords support to the original blood-clot and tends to prevent further extension of the aneurysm.

The presence of this change in the tissues is also an important element in the surgical treatment of the aneurysm. Even the process of exposure and delimitation of the sac is rendered more difficult by the swollen, indurated condition of the connective tissue, and the separation and displacement of muscles is interfered with by the firm adhesion between them and their sheath. Still more difficult in the earlier stages is the freeing of the blood-vessels themselves, since they are embedded in a mass of tissue like firm bacon, from which they can only be cleared by the use of the knife. It is this infiltration which renders operations for the suture of the vessels so difficult and

unsatisfactory, because it interferes not only with the insertion of sutures, which readily cut out, but also renders it a troublesome task to free the vessels sufficiently to approximate the ends without tension if any loss of substance has occurred.

Before passing on to a consideration of the signs and symptoms of traumatic aneurysm, the question of tardy development should receive some notice. It is a striking fact that the existence of an aneurysm is in so many cases not noted until days, weeks, or even months after the reception of the original injury. No doubt in many cases this is due to the small size of the sac, and to imperfect observation in consequence of the haste with which many patients with small wounds are necessarily evacuated. Giving due weight to this explanation, it is an undoubted fact that the development is sometimes a late one, and mention of the significance of incomplete lesions of the vessels in this relation has already been made. Another explanation of the tardy development of the aneurysm, however, is undoubtedly to be found in the secondary giving way of an originally perforating lesion in which the process of spontaneous healing commences and eventually fails. The most striking instances are afforded by the cases in which the original hæmatoma has been evacuated without the discovery of any bleeding point, and the wound has been allowed to heal. In connection with arteries, even of the magnitude of the external iliac, which were actually exposed during the process of clearing out the hæmatoma, a secondary aneurysm has been seen to develop several days later while the patient has remained under observation. A more common occurrence is the complete extinction of any local pulsation by pressure exerted on the main vessel owing to the rapid transformation of the effused blood into a firm coagulum. This pressure may suffice to prevent any passage of blood through the arterial wound, and thus lead to the extinction of the bruit, and may also obstruct the circulation to an extent involving loss of vitality of the limb (see *Fig.* 126, *Case* 75). Yet no signs of an aneurysm will be present, although such may readily appear at a later date when the absorption of the original blood-clot has allowed of sufficient dilatation of the lumen of the vessel for the restoration of the circulation.

Signs and Symptoms.—The obvious local signs of an arterial hæmatoma or a false aneurysm need no further description; but a few additional remarks may be devoted to two points—the characteristic arterial bruit, and the effect on the general circulation. The presence of this bruit indicates an incomplete solution of continuity, that is to say a lateral wound in the wall of the artery; it is in fact a sign of a wounded artery rather than of an aneurysm. It may be added that absence of a peripheral pulse is a less reliable sign of a complete solution of continuity, because this absence may result from external pressure upon the main vessel.

The systolic murmurs vary greatly in intensity, depth of tone, and musical character. As a rule, during the first few days they tend to be shrill and loud, and are audible along a considerable length of the vessel on the peripheral side of the wound. It is not common for the bruit to be conducted for any material distance centrally, and frequently it is scarcely audible a couple of inches above the situation of the wound. The character of the bruit obviously depends on the size and shape of the opening in the vessel and the

degree of irregularity of its margins. As the process of rounding off the ragged margins of the arterial wound progresses—a species of incomplete repair—the murmur tends to become softer and deeper in tone. The effect of diminution in size and increased regularity of surface of the blood cavity may also be a factor in the production of this change of character. It may be remarked that at the same period the heart's action is commencing to recover somewhat from the disturbance caused by the wound of the vessel and the resulting interference with the distal circulation, hence the pulse is less rapid and forcible. In the early period the heart in the great majority of cases is dilated, the apex-beat lying in the nipple line or outside it, and the cardiac action is tumultuous. A rise of the pulse-rate to from 90 to 120 is almost the rule, and the rapidity may persist for some weeks, especially if a septic wound is existent together with the aneurysm. As already mentioned, complete coagulation of the effused blood of the hæmatoma may cause a temporary or permanent cessation of the murmur; in the latter case it may be assumed that a chance of closure of the arterial wound exists. In cases where hard clot forms early, the consequent pressure on the arterial wound may not only prevent the further escape of blood, but also the production of a bruit. In these a murmur may develop later; hence the importance of repeated examinations.

The importance of auscultation as a means of determining the existence of a patent opening in the wall of an artery cannot be too strongly urged, since it is the only method of forming a certain diagnosis in some cases, for instance in a swollen thigh or calf in which no pulsation is detectable. I do not believe that the fact that external pressure on the vessel may give rise to a less definite murmur in any way invalidates this statement, for the bruit produced by pressure is rare, and far less loud and definite in character.

Progress and Complications.—It may be broadly stated that the typical course of an arterial hæmatoma is one leading to contraction and localization, a definite false aneurysm being the commonest final result. In the most fortunate cases the aneurysm itself may consolidate spontaneously, and a cure by natural processes occurs. Among the large arteries, this termination is most commonly met with in the lower few inches of the common femoral or in the upper third of the popliteal artery.

Certain complications, however, occur with some degree of frequency. The most common of these are symptoms dependent on the pressure of the effused blood and clot on neighbouring structures, the development of peripheral gangrene, the occurrence of secondary hæmorrhage, the detachment of emboli from the thrombus, and very rarely the sequence of inflammation from secondary infection. I propose to deal with these complications seriatim; but before proceeding to their consideration it should be pointed out that they occur for the most part during the stage to which the term arterial hæmatoma is strictly appropriate; that is to say, prior to the definite formation of the smooth secondary rounded sac which has been already described. When this sac has once become complete and of moderate thickness, the condition is far better described by the term false or traumatic aneurysm, and the development of a definite fibrous-tissue wall may be confidently expected. In this stage complications are not to be greatly feared—apart from the obvious

fact that the wall may be of insufficient strength to withstand the force of the circulation when active movements are resumed, and the aneurysm may consequently enlarge. For this reason it appears to be both proper and convenient to employ the terms exactly, and in relation to the stage of development which the condition has reached.

Pressure Symptoms.—The most common pressure symptom is naturally peripheral œdema, sometimes increased in consequence of concurrent injury to the vein. Occasionally, thrombosis of the deep veins may give rise to a tense persistent swelling of the limb, but this is not common, and in most instances depends on infection travelling from the wound. Pain from pressure on neighbouring nerves is not an uncommon symptom, but it is rarely persistent, and diminishes *pari passu* with the localization and contraction of the hæmatoma or aneurysm. It must be borne in mind also that the pain may depend on concurrent injury to a peripheral nerve.

The most serious effect of pressure is that dependent on obstruction of the blood-stream in the collateral branches of the artery, since this may lead to peripheral gangrene of the limb, not an uncommon occurrence in the lower extremity. This complication is more fully dealt with in the sections dealing with special vessels.

Secondary hæmorrhage may occur at two periods, either in the first few days, or after the lapse of a week or ten days. The earlier variety is the less important. It frequently consists in little more than leakage from a small wound during the early progress of contraction of the cavity: a small quantity of blood, really of the original effusion, may escape, soil the dressing for two or three days, and then entirely cease. It is important to appreciate that such leakages are no indication for operative measures, and that they are not to be regarded in the same light as small repeated hæmorrhages from a septic wound.

The later form of secondary hæmorrhage is vastly more dangerous. It may show itself in two forms, either a rapid extension of the swelling in the limb, or as external hæmorrhage. It is rare for this form of hæmorrhage to depend on septic infection of the aneurysm itself; it rather appears to depend on a defective process of localization which allows some part of the limiting boundary of clot to give way, often as a result of infection of the surrounding tissues, or as a result of a rise in the general blood-pressure accompanying increased activity, and perhaps from free movement of the limb on the part of the patient.

In some cases it appears to have resulted from the giving way of the actual line of union of small aneurysmal sacs such as are depicted in *Fig.* 124 from the original arterial wound, the margins of which have become thinned, smooth, and rounded in the process of repair. It may be repeated that the margins of the sac joining the circumference of the wound of the artery are the most tenuous part of the sac, while the dome opposite the opening, which bears the full force of the blood-stream, is the thickest. Again, in the process of cicatrization of a wound of the intestine, we know that the early connecting layer of lymph is strongest at the end of the third day, and that during the next four or five days, while the process of organization of the lymph into connective tissue is taking place, the union is perceptibly

weaker and less able to bear strain. A similar weakening of the line of union between the margins of the sac and the arterial opening may be safely assumed to take place while the same process of conversion of lymph into connective tissue is progressing, and the ease with which sacs can be swept off the vessel confirms this assumption. This is the dangerous period, which should be remembered as an indication for complete rest to the limb, the more so as it is obvious that the artery, even in its more fixed condition from surrounding infiltration of the vascular cleft, is yet a more freely movable structure than the sac when active muscular contractions occur.

While it has been stated above that infection of the boundary of blood-clot is infrequent, yet it must be borne in mind that the track of the missile may none the less be infected and remain unrepaired, thus not only weakening the support afforded to the clot by the surrounding tissues at a local spot, but also furnishing a ready path for the escape of the blood. As has been mentioned elsewhere, even an extensive cellulitis involving the whole limb only attacks the actual wall of the aneurysmal sac at a late date.

Late secondary hæmorrhages are extremely dangerous to the vitality of the limb, whether they take the form of extensions from the blood cavity, or of external bleeding, and may also cause grave risk to the patient's life.

The question of arterial thrombosis and *embolism* has been already dealt with under the heading of arterial contusion, and will be again referred to in the special sections.

Secondary Inflammation.—The rarity with which secondary inflammation occurs in traumatic aneurysm, affords one of the most striking proofs of the enormous capability of the blood, even when extravasated, to withstand and overcome bacterial infection. Among the whole series of cases dealt with in this communication, only two instances of death resulting from acute infection of the blood-clot were met with. In these cases the infection was anaerobic in nature. In one case blood-clot rapidly broke down into a brown fluid offering a strong resemblance to fæces, and the patient died from a sudden profuse secondary hæmorrhage (see *Case* 6 amongst the series of carotid aneurysms). It occasionally happens that a false aneurysm already localized becomes hot and reddened over the surface, and this must be regarded as an indication for active surgical treatment. In the only case operated upon for this reason, the aneurysmal sac itself afforded no signs of inflammatory change, and the operation wound healed by primary union (*Case* 51).

On the other hand, many cases came under observation, especially in the thigh, where widespread infection of the surrounding tissue had led to extensive suppuration, requiring free incisions for its relief, in which an existing large aneurysmal sac remained unaffected. In one instance anaerobic infection led to destruction of practically the whole of the musculature of the thigh, and yet an extensive aneurysmal sac failed to give way. It is clear that a strong distinction must be drawn between infection of the aneurysm itself and infection of the surrounding tissues.

The risks of infection are greatest during the arterial hæmatoma stage, when the collection of blood is large and the bounding layer of clot thin. Under these conditions the effusion of blood may increase in amount, or secondary hæmorrhage may occur. Either of these accidents may necessitate

an immediate ligature of the artery, and the cases are of a very unsatisfactory nature, since they are not infrequently followed by further secondary hæmorrhage, not from the point of ligature upon the main trunk, but from wounded collateral branches exposed in the septic original wound cavity which failed to bleed at the time of the operation.

ARTERIO-VENOUS ANEURYSM.

Arterio-venous aneurysms, although perhaps the most characteristic of all the after-results of gunshot wounds, are far less common than purely arterial aneurysms, and are as a rule a later development. In the latter respect they exhibit a sharp contrast with the allied condition of aneurysmal varix, the development of which commonly follows directly on the reception of the wound in the vessels.

Reasons have already been given for regarding the sac of a false arterial aneurysm as a secondary development from the stage of simple arterial hæmatoma, and there is evidence which suggests that the sac of an arterio-venous aneurysm is in the great majority of cases a virtually arterial sac developed in a similar manner. This evidence rests partly on direct observation of the condition of the wounds in the vessels at a certain stage, and partly on the mode of development of the physical signs.

First with regard to the nature of the wounds of the vessels. Any of the forms may be followed by the formation of an arterio-venous aneurysm.

1. If the lesion consists in a pure perforation of both artery and vein (a comparatively rare condition with the pointed German bullet), the aneurysmal sac will commonly be situated either on the distal side of the artery, or between the two vessels; or occasionally a sac may develop from either perforation in the artery; the wound in the vein away from the artery has usually cicatrized. The actual size of the aneurysmal swelling is increased by the dilatation of the lumen of the vein.

2. If the lesion consists in complete division of both artery and vein, a common cavity with which the four open vessels communicate may result. Under such circumstances the aneurysm is liable to retain for some time the characters of an arterial hæmatoma, it tends to extend rapidly, and gangrene of the limb or secondary hæmorrhage is not uncommon. Such cases are not numerous, and generally demand early surgical treatment, either on account of rapid extension, or the occurrence of one of the complications indicated. It is an interesting fact that under these conditions the peripheral circulation may sometimes be maintained by blood passing through the cavity intervening between the ends of the injured vessels.

3. In the great majority of cases the wound in the artery is lateral in character, associated either with a lateral wound, a double perforation, or complete division of the vein. Examples of this form of injury are seen in *Figs.* 126, 127, pp. 370, 373.

4. The sac may sometimes depend mainly on the venous injury, the vein being widely opened or completely divided, while only a small opening persists in the artery. In such cases the wall of the sac is thin and ill developed.

The case illustrated by *Fig.* 126 is a good example of delay in the formation of an arterio-venous aneurysm. The conditions for its development are present and favourable, but sufficient time had not elapsed for the process to be completed, or even actually commenced. The blood in the primary hæmatoma, as is often the case, had coagulated into a large firm clot in which no cavity existed. The clot exercised pressure, not only on the main trunk, but also on the collateral branches of the wounded vessel, and gangrene of the leg resulted, necessitating an amputation.

A second cause for delay in the development of arterio-venous aneurysms is found in a temporary closure of the openings or opening in the vein by a thrombus. Such occluding thrombi are naturally far more common in veins than in arteries, by reason of the lesser force of the venous circulation. It may happen that the opening into the vein is occluded by a foreign body; thus, in one instance operation on an apparently pure arterial injury disclosed a wounded artery, with the piece of shrapnel case which had caused it filling and controlling the contiguous opening in the vein.

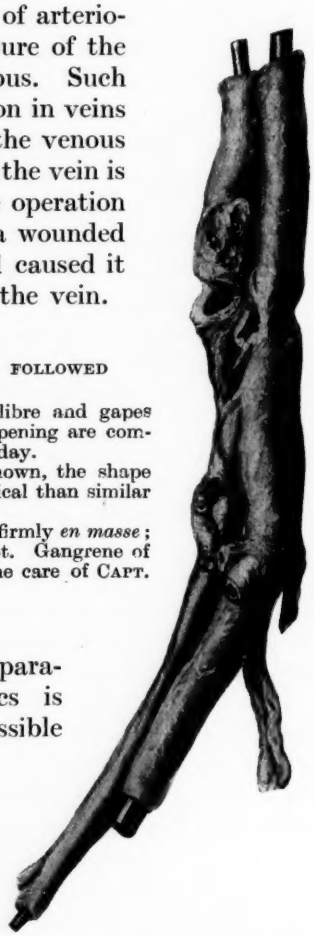


FIG. 126.—WOUNDED POPLITEAL ARTERY AND VEIN, FOLLOWED BY GANGRENE OF THE LEG (*Case* 75).

The wound in the artery involves nearly half its calibre and gapes widely, resembling a hole in a flute; the margins of the opening are comparatively smooth. The limb was amputated on the fifth day.

A characteristic traversing perforation of the vein is shown, the shape of the openings being irregularly circular, and less symmetrical than similar wounds produced in the artery.

The extravasated blood from these wounds had clotted firmly *en masse*; no murmur was audible in the swelling formed by the clot. Gangrene of the leg and foot was definite on the fourth day. (Under the care of CAPT. WEST, I.M.S., Meerut Stationary Hospital, Boulogne.)

The clinical evidence in support of the comparatively late development of arterio-venous sacs is equally strong. The first indication of the possible formation of an aneurysm is the presence of the characteristic systolic arterial bruit, a sign which can be detected prior to the appearance of either swelling or pulsation. In many cases the systolic bruit may become softer as the margins of the opening in the arterial wall become smoother in the process of repair, and then is replaced by the characteristic double murmur of the arterio-venous communication, and a bubbling thrill becomes palpable. This sequence of events may occupy a few days, or sometimes as much as a couple of weeks. I have observed it on many occasions.

Signs of Arterio-venous Aneurysm.—These are sufficiently familiar; but observation of a large number of cases has revealed some points of interest with regard to the characters of the murmurs which accompany the condition. The fact that the systolic element of the bruit may be audible first has already been dwelt upon. It remains to say that the characters of this may vary

considerably: it may be soft and musical, or harsh in sound. Sometimes it acquires a 'slamming' character, simulating in an exaggerated degree the so-called 'pistol shot' murmur heard in valvular disease over the aortic orifice of the heart. Such murmurs are associated with a highly excitable state of the general circulation and cardiac dilatation, conditions which in some degree accompany every traumatic aneurysm in its earlier stages. The increased rapidity of the pulse tends to settle down, but does not always subside at once even when the wound in the vessels has been dealt with by operation. It is much exaggerated in cases in which a septic wound complicates the aneurysm itself. The loud systolic murmur is conducted widely, usually peripherally, and to a much less extent centrally; but in exceptional cases it may be transmitted centrally, even from the thigh to the heart's apex. This latter phenomenon is always of a temporary nature, lasting not more than three or four days. The diastolic roar is conducted in either direction, but as might be expected, more freely in a central direction in the vein. It is always loudly audible in the opposite side of the neck in cervical aneurysms, and when the aneurysm is at the root of the neck, may be audible over the whole cardiac area, quite separately from the normal valvular sounds of the heart itself.

In some instances the murmur may be conducted by the whole mass of the tissues of the limb, and be audible wherever the stethoscope is placed upon the surface. In these, the sound may be heard even when the ear is in neither direct nor indirect contact with the limb. These phenomena are more common in the lower limb, and in the early or arterial hæmatoma stage when a large collection of effused blood is present.

As a rule, the murmur is only conducted along the actual line of the peripheral vessels; and the presence of the bruit either at the wrist or the ankle is a valuable indication of the persistence of a column of blood in the vessels when the amount is of insufficient volume and force to be palpable as a pulse.

The height of pitch of the murmur is a valuable guide to the exact site of the arterio-venous communication. It is highest and loudest immediately over this spot, the tones gradually softening and deepening in either the upward or downward direction as the stethoscope is moved along the lengthening column of blood in the course of the vessels.

Bubbling Thrill.—What has been said as to the development of the murmur holds equally good for that of the thrill. It is not detectable in the earlier stages, as is the case with the aneurysmal varices, and it tends to become stronger during the first days. Thus, while one day it may be scarcely palpable, and of the slight 'faradic current' type, over a popliteal aneurysm where pulsation in the tibial vessels is absent at the ankle; on the following day, with the reappearance of the pulse, the thrill may be comparatively strong. The thrill is not a valuable localizing sign, and is in no way comparable to the pitch of the murmur as indicating the actual point of communication of the artery and vein.

Obvious signs of obstruction to the peripheral venous circulation are rarely present in the early stages of an arterio-venous aneurysm, except in the form of general swelling of the limb. Extensive thrombosis is occasionally met with, but usually in connection with a septic wound.

The process of gradual contraction and consolidation of the sac differs little from that already described in the case of pure arterial traumatic aneurysm; but the progress to spontaneous consolidation and cure observed in the latter is rarely or never seen in the arterio-venous variety. The resumption of active life on the part of the patient is therefore liable to be followed by increase in the size of the aneurysm, and the development of pressure symptoms or those of venous obstruction. Such secondary effects are much more marked in the lower extremity than in the upper.

ANEURYSMAL VARIX.

The establishment of a direct lateral anastomosis between a contiguous artery and vein is the most remarkable result of gunshot injuries to the vessels. The occurrence is in great part dependent on the anatomical arrangement of the two vessels, viz., contiguity and parallelism of course, and the most typical examples are seen when the missile passes between the artery and vein, causing a lateral wound in both. *Fig.* 127 depicts an aneurysmal varix of this class; it will be seen that a transverse slit wound has been caused in the artery, and a roughly stellate one in the less brittle vein. Examination of the carotid sheath and vascular cleft showed that absolutely no bleeding had taken place into the tissues, and that direct primary adhesion between the margins of the wounds of the two vessels had resulted. No better anastomosis could have been established by the most skilful surgical operation. A similar observation was made in a case of femoral varix included in Surgeon-General Stevenson's Report on the surgical cases noted in the South African War. The frequency with which such primary adhesion without the occurrence of hæmorrhage takes place is further supported by the number of cases reported in which surgeons have failed to discover the actual point of communication between the two vessels, even when exposed by an open incision. I have myself suffered the same experience in a case of femoral varix, reported below. The direct nature of the adhesion between the vessels sufficiently explains the fact that the signs of an aneurysmal varix are developed immediately after the reception of the injury in the great majority of instances. The only secondary change which develops under these circumstances is a dilatation of the lumen of the vein, with thickening of its wall. The dilatation may be sufficient to create suspicion as to the presence of an aneurysmal sac, the more so as the arterial pulsation is communicated to the enlarged vein. Aneurysmal varices may perhaps sometimes follow wounds in which such accurate primary adaptation of the two vessels is impossible; in such instances the development of thrill and murmur may be a later event. Under these circumstances one can only suppose either that the union and cicatrization has been effected under a mass of blood-clot, such as has been described as present at a certain stage in the development of the traumatic aneurysms, but in which no secondary cavity has been formed; or that a temporary venous thrombosis occurred. A case of injury to the innominate vessels, in which a thrill and double murmur developed at a late period, is quoted on p. 376. Here no evidence of an aneurysmal sac could be detected, but as the lesion was within the chest, one cannot be certain on this point (*Case* 1).

An extended experience of cases of aneurysmal varix has led one to doubt, however, whether this condition often develops except in instances in which the vessels are wounded by a missile which passes between the artery and the vein implicated, or in the rare instance of a perforation of both vessels from side to side, in which the two outer openings cicatrize while those in the contiguous side of the vessels adhere. As to the occurrence of the latter process, I have no experience; but if a pure aneurysmal varix is eventually

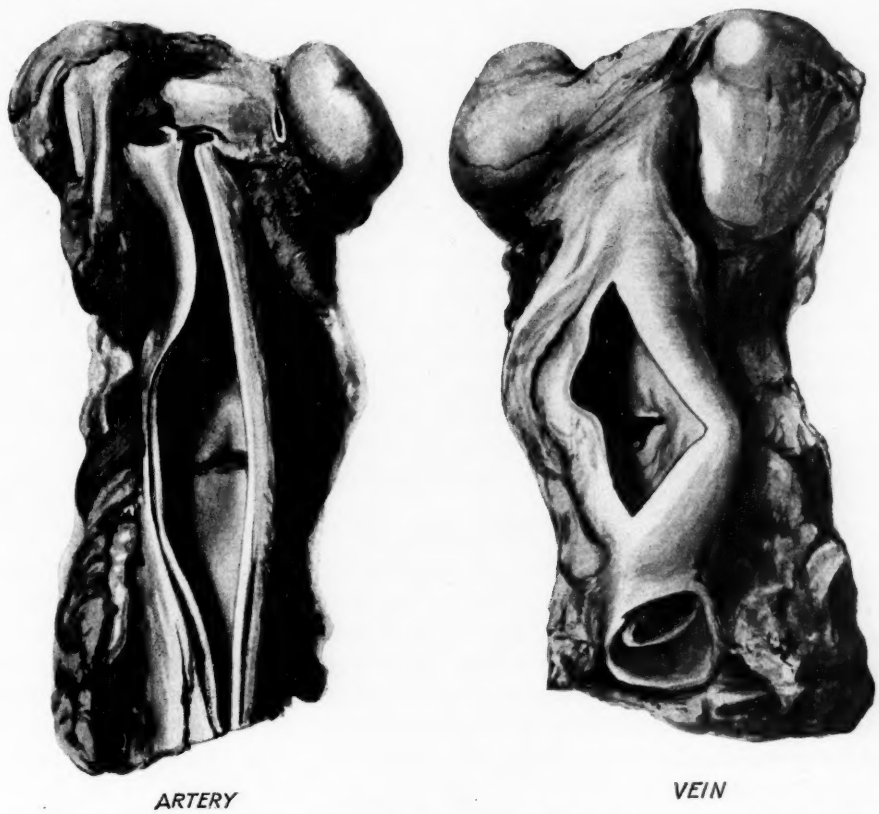


FIG. 127.—ANEURYSMAL VARIX OF THE LEFT COMMON CAROTID ARTERY AND INTERNAL JUGULAR VEIN (*Case* 4.)

A simple transverse lateral slit is seen from the interior of the artery, and a roughly stellate opening from the interior of the vein. No blood had been extravasated into the vascular cleft, and adhesion between the two vessels was immediate and complete.

The typical signs of a carotid aneurysmal varix were present. The patient died on the seventh day from concurrent injuries to the head. (Under the care of MAJOR PARSONS, No. 11 General Hospital, Boulogne.)

developed, I am inclined to think it usually follows the spontaneous consolidation of a false aneurysmal sac on the free side of the artery.

A case such as that depicted in *Fig.* 130, p. 381, offers a considerable field for speculation; here no aneurysmal sac had developed at the end of the eighth day, neither was there any collection of blood in connection with the wounds in the vessels except that enclosed in the sheath of the left vagus. The track leading from the arterial wound into the larynx had remained

narrow—so narrow, in fact, that it was only discovered by a very careful search when the specimen was dissected. It seems possible that a permanent indirect aneurysmal varix might have been developed here; or an arterio-venous aneurysm, the sac of which occupied the distended sheath of the vagus, might have formed between the vessels; or again, a sac might have developed between the wound of the artery and the larynx.

The presence of an aneurysmal varix may be accompanied by no further physical signs than the double murmur and bubbling thrill. What has been said regarding these signs under the description of arterio-venous aneurysm applies equally well to aneurysmal varix. Besides these phenomena, some swelling usually exists due to dilatation of the vein in the vicinity of the communication. When this dilatation is considerable, communicated pulsation from the artery may raise the question of the existence of an aneurysmal sac. The dilatation of the vein may persist in the rare cases in which the arterio-venous aperture closes spontaneously (Sir W. Osler, *Lancet*, 1913, vol. ii, p. 1248).

In the early stages some general swelling of the limb may be met with, due to the disturbance of the normal venous circulation. In the upper extremity this swelling is often quite temporary, but in the lower limb it may be more or less persistent, and at a later date the superficial veins may develop varicosities. A sense of weight in the limb, or more rarely actual pain, may call for operation; but the condition is rarely sufficiently serious to make such a procedure necessary.

GENERAL TREATMENT OF VASCULAR LESIONS.

I do not propose to treat this question at any length, first of all because the cases on which this paper is founded have been observed during a very short part of their course, and even in the instances in which early operative interference has been necessary, I am unaware as to the final influence exerted by the operations on the general nutrition of the parts supplied by the peripheral circulation. The bald facts observed as to the frequency of gross secondary lesions, such as gangrene or secondary hæmorrhage, are recorded in the special sections.

Again, with regard to the primary treatment of wounds of the large arteries I can say little, except that the immediate ligation of large trunks has not been a very successful measure, and that where a proximal ligature at the seat of election has been employed, I have seen several cases arrive at the general hospitals with incipient or definite gangrene, even in the case of the upper extremity. It is clear that immediate ligature of the large trunks under the conditions of military surgery is often followed by a want of compensation on the part of the collateral circulation, and beyond this, that the prospects of success are jeopardized by the circumstance that such operations need to be performed at a moment when the patient is suffering from a general loss of blood. This is especially notable in the case of ligature of the common carotid artery, which is followed by cerebral softening to a degree quite unapproached by what is familiar after operations for the cure of aneurysms of lengthy duration. In one case in which the common

carotid needed to be ligatured on the third day as a result of the relief of pressure on the wounded spot consequent on the removal of a piece of shrapnel case from the neck, the patient died within forty-eight hours, and the softening extended to the basal ganglia on the opposite side of the brain (Lieut.-Col. Cameron).

As to the treatment of secondary hæmorrhage, there is nothing special to be recorded.

The primary treatment of an arterial hæmatoma should be rest and an expectant attitude. Ligature of the artery at an early date is objectionable if it can be avoided; not only has the collateral circulation not acquired sufficient compensatory enlargement, but the conditions for the proper fulfilment of this process may be seriously interfered with, either by pressure from the blood-clot around the wound in the vessel, or, still more seriously, by concurrent wounds, or laceration from tearing, of some of the collateral branches themselves. As a result of these conditions, under the best of circumstances the general nutrition of the limbs suffers permanent injury, and actual gangrene is not infrequently the result. Beyond this, if wounded collaterals lie in the wall of the cavity of the hæmatoma, they may not bleed at the time of ligature of the main trunk, and hence are a not infrequent source of secondary hæmorrhage. I have seen the latter result on several occasions, where the ligature of the artery has been necessitated either by rapid extension of the hæmatoma, hæmorrhage, or a septic condition of the accompanying wound of the soft parts. An arterial hæmatoma should only be interfered with under one of the latter conditions, either of which may render a prompt operation unavoidable.

The large majority of the hæmatomata eventually become false aneurysms. For this condition, also, an expectant attitude is the best for some weeks; if during this time steady decrease in size and increase in the firmness and solidity take place, a much longer period should be allowed to elapse, in the hope that spontaneous consolidation of the sac, with persistence of the lumen of the artery, will supervene. Such an occurrence is not very rare, and the result is far superior to any obtainable by ligature or excision, and probably in no way inferior to that to be attained by successful suture of the opening in the arterial wall. Again, the later the date (within reason) at which the operation is undertaken, the better are the prospects of finding the vessel sufficiently free in the vascular cleft to allow a fair trial of the operation of suture. In certain positions a proximal ligature at the seat of election suffices to cure a false aneurysm, but the method is uncertain, and should not be adopted in any situation where the sac and the opening in the vessel can be dealt with locally.

There is no material difference in the early treatment of arterio-venous aneurysm; it needs only to be borne in mind that spontaneous cure is not likely to occur, and that proximal ligature of the artery, especially in the lower limb, is to be avoided, as gangrene of the limb was a common result of this treatment during the South African campaign. A local operation, with ligature of both vessels above and below the communication, or some form of suture, is the proper treatment for the condition. *B* and *E*, *Fig.* 123, p. 360, show well the danger of limiting the operation to double ligature of

the artery alone. The branch arising in immediate proximity to the wound in the artery would certainly, if not ligatured, have ensured the persistence of at any rate the signs of an aneurysmal varix.

Aneurysmal varices never need early treatment, and it is rare that an operation is required at a later date. The communication may close spontaneously, even after a long interval. Operation is needed most often in the lower limb, and should be of the same character as that recommended for arterio-venous aneurysms.

I much regret not being able to give any information regarding the treatment of gunshot wounds of the arteries by direct suture. In the cases I have myself seen, the nature of the defect in the arterial wall, the condition of the surrounding tissues, or the fact that the septic condition of the primary track afforded small hopes of performing an aseptic operation, militated against the choice of the method. In two cases which I saw some weeks after the operation, no peripheral pulse was present, suggesting that local thrombosis had vitiated the objects aimed at. An examination of the published results attained during the Balkan War also appeared to me inconclusive. Prof. Bier, at Brussels, in 1915, designated suture 'the operation of the future;' but no details of his cases have come to hand, and he admitted that thrombosis had occurred in a certain proportion. He also says that a circular suture is often needed, which observation is no doubt true. It would also be interesting to know whether the positions of flexion necessary to allow union of the line of suture in the absence of tension, have not resulted in furnishing the additional difficulty of straightening out a contracted limb.

PART II.

INJURIES TO THE VESSELS OF SPECIAL REGIONS.

Before proceeding to a consideration of certain points peculiar to injuries of the vessels of different regions of the body, it may be well to emphasize the fact that the material on which this paper is based has been gleaned from observations made in the general hospitals only. It seems necessary to repeat this statement, lest any attempt should be made to found statistical conclusions on the numbers to be obtained from the tables at the end of the paper. These tables leave out all reference to the nature or results of any treatment of arterial wounds that may have been carried out as a matter of urgency at the field ambulances or casualty clearing stations; hence they only deal with cases during a certain limited period of their course, and that one in which the immediate dangers of the injuries have been already surmounted. Again, with regard to the nature and distribution of the injuries, it will be at once evident that those included furnish an incomplete record only, and that complete divisions of the smaller vessels, although common, are unrepresented.

Innominate Vessels.—The only case is one of aneurysmal varix.

Case 1.—A man was admitted with a small slit entry wound situated over the left sternoclavicular joint. The missile was retained and its position was never discovered. The patient was suffering from an extensive right hæmothorax and was very ill. During the next ten days he improved, and meanwhile the whole chest was examined almost daily, and was also aspirated.

On the eleventh day a double machinery murmur was heard for the first time by Capt. T. R. Elliott, under whose observation the man had been since his admission. The systolic element was of the 'slamming' or 'pistol-shot' character, the roar was conducted loudly to both sides of the neck and to the base of the heart. A bubbling thrill was palpable in the line of the right axillary vein. A week later there was little change, except that the thrill was now felt only in the line of the jugular vein in the neck, and that the murmur was louder and more definitely localized over the line of the innominate vessels. No local dullness was to be detected beneath the first piece of the sternum or inthe upper right intercostal spaces. The patient was shortly afterwards transferred to England.

There are only two comments to make on this case. With regard to the doubt as to the localization of the arterio-venous communication aroused by the fact that the bubbling thrill was first palpable over the right axillary vessels, I think I may have been deceived as to the actual localization, the more so that the permanent thrill in the jugular took up the direct line of the innominate vessels, and it is possible that what was first felt was innominate and not axillary.

The other point is the late advent of the signs of arterio-venous communication, a phenomenon suggestive rather of an aneurysm than a varix. As to this feature, I think the case should be considered in connection with the left subclavian injury (*Case* 16, p. 358) and the right subclavian aneurysm (*Case* 17, p. 385), in both of which a hæmothorax co-existed and was discovered many days prior to the signs of aneurysm. As in those instances, it appears probable that the blood from the wounded vessels trickled steadily into the pleural cavity, and no opportunity existed for the formation of local clot or the development of a local aneurysmal sac. Only when the pleura was distended, so that resistance to the further entry of blood was developed, did the local changes necessary for the completion of the conditions antecedent to the formation of an aneurysm or varix become established.

This is the only innominate varix I have met with during the thirteen months I have been on the look-out. The single instance I observed in South Africa eventually underwent spontaneous closure five years later.*

Carotid Vessels.—This series consists of fourteen cases, including one of the internal and two of the external carotid artery. Eight were of the right, and six of the left, vessels. Six of the injuries to the common carotid were to the upper third of the vessel, three to the middle part, and one to the lower third. In two cases the bullet took a vertical course from the head to the root of the neck: in one of these the centre of the vessel appeared to be the part wounded, in the other the injury was really to the thyroid vessels. Ten of the injuries were caused by bullets, and five by shell fragments: two of the bullets and four of the shell fragments were retained. Two cases were instances of contusion causing thrombosis and cerebral embolism. As a result of the wounds, false arterial aneurysms followed in two cases, arterio-venous aneurysms in three, and the clinical evidence was in favour of aneurysmal varices in seven. The great preponderance of the latter condition is a striking feature; though if the opinion expressed in the general section as to its causation is correct, no doubt the carotid vessels are so arranged with

* *Surgical Experiences in South Africa*, 1899–1900, 2nd edition, p. 140.

regard to the internal jugular veins as to allow the passage of the missile between the two vessels to be easy.

Five deaths occurred in the series, three from secondary hæmorrhage, one from acute infection of the clot, and one from cerebral embolism following on contusion of the artery.

Only two cases were operated upon, both by simple ligature of the common carotid for arterial aneurysms. One operation was for an aneurysm of the internal carotid, and was completely successful, the other was followed by hemiplegia due to a cerebral embolus.

FIG. 128.—A DISSECTION OF THE NECK, SHOWING THE APERTURE OF EXIT OF A BULLET TRACK CROSSING THE COURSE OF THE RIGHT CAROTID ARTERY AND INTERNAL JUGULAR VEIN, AND ESTABLISHING A COMMUNICATION BETWEEN THEM.

A glass rod projects from the track, and the blood-clot seen in the opening is in direct continuity with the wound in the vein. The arterial wound has not been exposed.

The wound underwent anaerobic infection, and the patient died from secondary hæmorrhage, associated with left hemiplegia, on the sixth day (*Case* 6). (Under the care of LIEUT.-COL. BUTLER, No. 13 Stationary Hospital, Boulogne.)

Little requires to be specially mentioned with regard to the signs and symptoms in these cases: all were typical, but it is worth recording that only one of the ten patients in whom arterio-venous communications existed complained of hearing the buzzing of the murmur, and in this man the trouble only persisted for a few days. The pulse-rate was augmented, but in most of the cases only from 80 to 100, once to 120. It is noteworthy that in the two cases of contusion followed by cerebral embolism the pulse-rate was 120

and 140 respectively; in the latter, death was imminent when the patient was seen.

Complications.—These were of much greater interest, and deserve a short recital of the cases in which they occurred.

1. Infection of the Primary Blood Effusion.

Case 6.—(Under the care of Lieut.-Col. Butler.)

The patient was wounded two days prior to admission; there was no information as to the occurrence of primary hæmorrhage, but the patient was ill and very anæmic. Temperature 101°; pulse 104.

Fig. 129.—A Mesial Section of the same Neck.

A glass rod in the retropharyngeal space indicates the central portion of the track of the bullet. The retropharyngeal space itself is highly distended by gas emanating from the action of anaerobic bacilli, but no pus was present in the space. The condition illustrates well the fact that the extension of the gas precedes that of actual invasion of the tissues by the anaerobes, and renders the latter process more easy and rapid. (Under the care of Lieut.-Col. Butler, No. 13 Stationary Hospital, Boulogne.)

A circular wound two and a half inches in diameter existed at the posterior border of the sternomastoid, two inches above the clavicular origin of the muscle. A small entrance wound at the back of the neck was closed. From the wound a dark brown discharge with a strong fæcal odour was escaping; the nurse indeed said that 'fæces' were coming out of the neck. *B. aerogenes capsulatus* was cultivated from the fluid.

Four days after the reception of the wound a sudden severe secondary hæmorrhage took place. This was arrested by plugging the wound with gauze soaked in

adrenalin. On removal of the plug the next day, some pulsation was noticed, and auscultation revealed the presence of an arterio-venous double bruit. Shortly afterwards the patient became hemiplegic, and he died on the sixth day.

The right side of the neck is shown in *Fig.* 128. The opening, still occupied by blood-clot, is exposed, and leads down to an opening in the internal jugular vein ; the wound in the artery was not exposed. No laminated cavity had been formed ; hence the condition was still that of an arterial hæmatoma, in which the rare accident of acute infection had occurred. The hemiplegia was no doubt embolic in origin, but unfortunately no examination of the brain was made.

Fig. 129 is of much interest as illustrating the size which collections of gas may reach in suitable situations in *B. aerogenes capsulatus* infections. The large space behind the pharynx and œsophagus contained gas only.

The case illustrates also the two further complications about to be considered.

2. Secondary Hæmorrhage.

Case 8.—(Under the charge of Capt. Oliver.)

A man was admitted three days after the reception of a transverse bullet-wound of the neck. The aperture of entry half an inch below the upper margin of the left ala of the thyroid cartilage, and the aperture of exit at the margin of the right trapezius muscle, two and a half inches above the clavicle, were both minimal in size, and closed.

The skin of the left side of the neck was of an orange tint from fading ecchymosis, and there was some general swelling of the neck, but no localized tumour or expansile pulsation. The man was breathing quietly, but the voice was hoarse and low, the latter fact being ascribed to recurrent laryngeal paralysis. The pulse was 120, of fair strength, and regular. On auscultation a loud double arterio-venous murmur was heard, most marked at the posterior border of the left sternomastoid muscle, in which position a bubbling thrill was also palpable and strong.

The man showed little distress, and for the next four days lay quietly in bed, the swelling of the neck steadily decreasing. He took his food easily, the breathing was practically normal, and no suspicion arose that the vascular injury was not settling down as is usually the case.

At 8 p.m. on the tenth day after the injury, without any warning, about half a pint of bright blood was coughed up. I saw him at 9 p.m. when, except that he was rather excited, he seemed little changed. In view of the amount of blood coughed up, it appeared advisable to ligature the root of the carotid artery, or possibly deal directly with the wound in the vessels.

Open ether narcosis was chosen and the man was anæsthetized, nothing special being noted in the breathing except that the inspirations were shallow and the patient went slowly under the influence of the anæsthetic. As the first incision was made the man ceased to breathe, and since there was evidently mechanical respiratory obstruction, I opened the trachea. Much fluid blood and clot escaped, but no relief was afforded, and the man died.

At the autopsy, the trachea and all the bronchial tubes were found full of blood and clot, there was massive collapse of the lower lobe of the right lung, and localized patches of collapse in both right and left lungs. An enlarged thymus was present, and some post-operative ecchymosis of the mediastinal tissues. Beyond the presence of some enlarged mesenteric glands no further visceral disease was discovered.

The condition of the vessels is shown in *Fig.* 130. A double perforation of the vein and a lateral wound of the carotid were present, while the two vessels were separated by the left vagus nerve. The latter had been perforated, and beyond the blood which had collected within the confines of its

sheath, no hæmorrhage of any moment had taken place into the vascular cleft. It is difficult to say whether the later condition in this instance would have been an arterio-venous aneurysm, the sac of which was in part formed by the sheath of the vagus; but up to the time of death it can only be regarded as an early indirect aneurysmal varix. The quiet manner in which sufficient hæmorrhage occurred to flood the lungs and drown the patient is very remarkable, since the man was under constant opportunities of being seen by the nurses, as well as by his neighbouring fellow-patients, in a large, well-lighted ward, and it is clear that the process produced neither discomfort nor distress. I believe this is to be explained by the anæsthetic condition of the larynx, which was pierced through the area of distribution of both superior laryngeal nerves. The recurrent laryngeal paralysis was probably due to the direct injury to the left vagus, and not merely to concussion of the larynx.

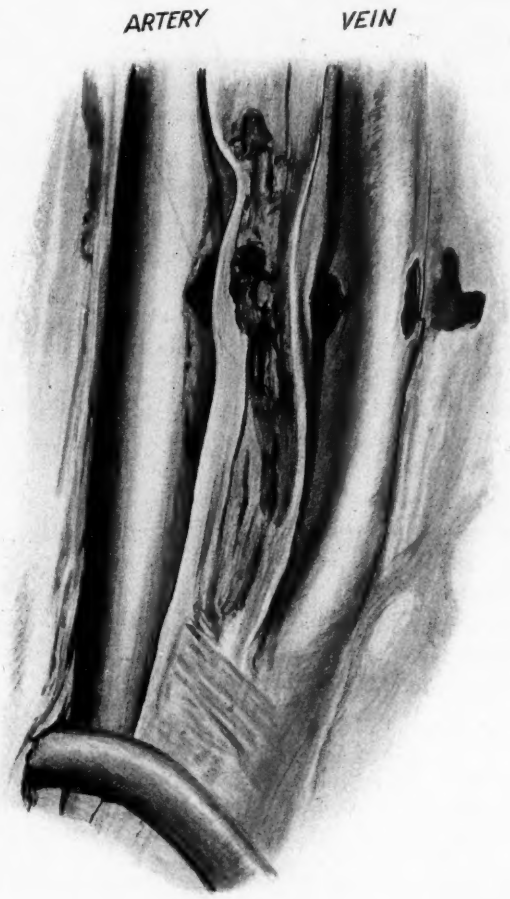


FIG. 130.—WOUNDS OF THE LEFT COMMON CAROTID ARTERY AND INTERNAL JUGULAR VEIN (*Case* 8, p. 380). (*Twice the natural size.*)

A traversing perforation of the vein is seen, with fairly symmetrical openings, and a lateral transverse wound of the artery. Between the vessels the left vagus is shown, greatly enlarged by the extravasation of blood into its sheath

The signs were those of a typical carotid aneurysmal varix; no symptoms attributable to the vagal injury were noted beyond hoarseness of voice from abductor paralysis. The patient died from secondary hæmorrhage. (Under the charge of CAPT. OLIVER, No. 13 General Hospital, Boulogne.)

The secondary hæmorrhage was of the class which may occur when the process of formation of a false aneurysm in connection with a wound in an artery is either retarded or absent. There is no evidence that infection of the wound was in any way to blame; it is probable that the healing of the track leading from the larynx to the artery was retarded by the normal movements of respiration and deglutition, while the wound in the artery itself received support neither from coagulated blood nor from the reactionary infiltration of the tissues which usually reinforces the pressure exercised by the clot. It should be noted also that this patient had a pulse of about 120, which may also have had an influence on the occurrence of the bleeding.

Case 14.—(Under the care of CAPT. MUMFORD.)

A man was admitted two days after receiving a bullet wound. The bullet struck the tip of the nose, passed through the upper lip, wounded the tongue, and then entering the sinus pyriformis, travelled vertically down the neck. Its final resting place was never localized.

There was considerable swelling of the right side of the neck, and some ecchymosis, but no evidence of the existence of an injury to the carotid vessels.

On the third day after admission two severe attacks of dyspnœa and some hæmoptysis occurred. In the second of these the man died.

At the autopsy, the trachea, bronchi, and lungs were swamped with blood, and there was septic pneumonic consolidation of both bases. Extravasated blood was present in the neck and in the anterior and middle mediastina. A large amount of blood had also trickled down the gullet, and the stomach was loaded with clot. No injury to the main carotid trunks had occurred, but the thyroid gland was much lacerated, and its capsule bounded a large hæmatoma.

In this instance again, the uneventful development of the hæmorrhage was very striking. Until the first attack of dyspnœa the man appeared to be progressing well, and the moderate hæmoptysis excited little suspicion. There is no doubt that commencing infection influenced the occurrence of the secondary bleeding, and was perhaps mainly responsible for it.

The gradual unnoticed filling up of the lungs and stomach by blood welling up from the wound in the fossa pyriformis, I believe again to be explained by the presence of anæsthesia in the area of distribution of the superior laryngeal nerve consequent on the wound of the pyriform fossa and larynx.

3. EMBOLISM.—The occurrence of arterial embolism in contusions of the carotid arteries, in connection with an arterio-venous aneurysm, has already been referred to under the heading of contusions of the vessels; it may be worth while to complete this subject by quoting briefly a case in which the same accident followed ligature of the carotid for a false arterial aneurysm.

Case 2.—(Under the charge of CAPT. FITZMAURICE KELLY.)

A man was admitted on the fourth day after receiving a wound at the level of the upper margin of the right ala of the thyroid cartilage. The missile was retained. The blood spurted 'as from a tap' at first, and the patient fainted, but a pad was applied and hæmorrhage ceased permanently.

On admission, a pulsating tumour two and a half by three inches was present at about the level of the top of the thyroid cartilage; there was a little general œdema of the side of the neck, and ecchymosis along the line of the vascular cleft, extending down over the front of the first piece of the sternum. A loud simple systolic bruit was audible on auscultation. The patient improved when kept at rest, the pulse averaging 88, and the œdema of the neck decreased.

On the ninth day, some evidence of extension along the line of the vascular cleft suggested the wisdom of ligaturing the artery, and this was done by Captain Kelly. The ligature was placed below the omohyoid, and pulsation in the aneurysm ceased. The patient progressed well for four days, the aneurysm solidified, and feeble pulsation could be detected in the distal portion of the carotid.

On the fifth day after the operation, the patient, who had been bright and well all the afternoon, suddenly became drowsy and hemiplegic. On the twentieth day he was transferred to England, in fair bodily and mental condition, but still completely hemiplegic.

Prognosis and Treatment.—The series affords little opportunity for remarks, but some points may be considered.

First, as to primary ligature of the wound in the artery, it might be argued that the occurrence of secondary hæmorrhage in two out of fourteen

cases indicated the danger of expectant treatment. I would only point out that the primary infection in *Case* 6 would probably have rendered the proceeding nugatory, and that in *Case* 8 a primary operation might have proved a procedure of much risk and difficulty. Further, primary ligature for gunshot wounds has acquired a very unenviable character, from the frequency with which it has been followed by cerebral softening and death

FIG. 131.—ARTERIO-VENOUS ANEURYSM OF THE EXTERNAL CAROTID ARTERY.
The small aperture of entry is seen anteriorly (*Case* 10). (Under the care of MAJOR SHEA, Rawul Pindi Hospital, Wimereux.)

of the patient. I only happen to have seen one case of this character, where the removal of a fragment of shell relieved a wound in the carotid from pressure, and the hæmorrhage demanded an immediate ligature. The patient died forty-eight hours later, and at the autopsy the cerebral softening involved not only the corresponding cerebral hemisphere, but also the basal ganglia of the opposite side.

Practical experience has shown that the danger of cerebral anæmia and softening is very greatly lessened if time has been allowed for the patient to recover from the primary general anæmia, and for the collateral vessels to become enlarged.

Of the cases related in an earlier paper on this subject,* no untoward accident followed the only three cases treated by primary proximal ligature, and in two arterio-venous aneurysms the anastomotic communication which again became evident a short time after the operation closed spontaneously during the course of the succeeding twelve months. One of the two latter patients is now on active service in France. I am not prepared to suggest that it may not be better in suitable cases to ligate the vessels above and below the aneurysm; in fact, in the case just related (*Case* 2) the adoption of this course would have probably prevented a very serious complication, that of cerebral embolism. Still, I think the more extensive operations must be used with judgement, since they are obviously much more risky procedures if a large sac is present. As to the ideal operation of suture of the wound in the vessel, I have no experience.

Aneurysmal varices should in my opinion be left alone, unless they are causing obvious trouble.

Subclavian Vessels.—The series contains seven cases of injury to the subclavian vessels, four caused by bullets, three by shell fragments. Five were of the right artery, two of the left. One involved the vessel in the first part of its course, two in the second part, and four in the third.

One of the cases was a simple division of the artery, in which spontaneous cessation of the hæmorrhage took place. In one, a large hæmothorax took the place of an ordinary arterial hæmatoma. Of the remaining five cases, in three an arterial hæmatoma and resulting false aneurysm developed, and in two an arterio-venous aneurysm.

The complications consisted of a concurrent hæmothorax in two cases, a concurrent injury to the brachial plexus in two, a brachial embolism in one, and secondary hæmorrhage and death in one. One other death followed upon an operation, from hæmorrhage.

Case 16, in which a brachial embolism occurred, has been already related in the section relating to arterial embolism in general, but a remark may be added as to the presence of the hæmothorax in this patient. It is reasonable to assume that the hæmothorax took the place of the ordinary hæmatoma usually situated amongst the tissues. In a similar instance I observed in South Africa the termination was still less happy, since the man died from secondary hæmorrhage some days after an incision.† In the case under comment the man escaped this accident, in spite of the fact that the hæmothorax suppurated and required to be drained. The wound in the artery presumably healed spontaneously.

Case 18.—(Under the care of Lieut.-Col. Gordon Watson.)

This case is worthy of comment in that it is an instance of a large wound of the second part of the artery in which the extravasated blood clotted completely without the formation either of a pulsating tumour or the development of a bruit

* *Surgical Experiences in South Africa*, 1899–1900, 2nd Ed. † *Ibid.* p. 128.

to arouse suspicion. The fragment of shell entered and became embedded in the posterior triangle. Some free hæmorrhage which accompanied the removal of the fragment was checked by plugging the wound. An extensive cellulitis requiring incisions followed this procedure, but the patient was progressing well until the tenth day; on this day, as on the twelfth and fourteenth, secondary hæmorrhage followed the removal of the dressings, the blood coming out with 'a swish.' On the fifteenth day an attempt was made to deal directly with the wounded point, but when the wound was opened up the bleeding was so sharp, and the infiltrated tissues so difficult to deal with, that the operation had to be abandoned and the wound again plugged. The man died the same evening.

At the autopsy, pus was found both in the anterior and posterior mediastina, whence indeed it had flowed freely during the last short operation. A flap-like wound involving two-fifths of the circumference of the artery on the mesial side of the origin of the superior intercostal artery was found (see *Fig.* 123, *C*), and also the two firmly-healed ends of the completely severed subclavian vein.

The case is instructive as illustrating the fact that concurrent wounds of the artery and vein are by no means always followed by the development of an arterio-venous aneurysm, especially when the vein has been completely divided. The flap-like character of the arterial wound was perhaps such as to allow the vessel to have healed without the eventual development of an aneurysm at all.

To Lieut-Col. Gordon Watson I am also indebted for permission to quote the following case of complete division of the third part of the artery.

Case 104.—The patient was admitted with a brachial monoplegia and absent radial pulse. At an operation done for the repair of the divided cords of the brachial plexus, it was discovered that complete severance of the artery had been effected by the bullet, and followed by no serious hæmorrhage, either external or into the tissues. The mesial end of the vessel had retracted beneath the anterior scalene muscle, the distal end was seen curled up at the lower end of the operation wound.

In connection with these three cases, a fourth (*Case* 17), under the care of Lieut.-Col. Butler, in which a right hæmothorax, preceded by hæmoptysis, followed on a bullet wound of the right posterior triangle, is worthy of mention. The interest lies in the fact that no aneurysm was discovered until three weeks after the patient's admission to the base hospital, although the condition of the patient's chest required a daily examination, and the course of the bullet, entering at the outer part of the sternomastoid and emerging at the superior angle of the scapula, had suggested an injury to the great vessels. When detected, it consisted of a small, hard, rounded swelling one and a half inches in diameter. The pulsation was scarcely expansile in character and not strong, but a very loud systolic murmur of the 'pistol-shot' type, conducted both upwards to the neck and downwards into the arm, was audible on auscultation. The radial pulse was good, perhaps a little weaker than the left. The patient was transferred to England, and the aneurysm was of the type in which spontaneous consolidation is possible. Its late appearance may have been due to the fact that the conditions favouring the early development of a sac—viz., the support of the surrounding tissues and the influence of the boundary formed by them in producing an early coagulation of the effused blood—were absent; while in their place the right pleura formed a potential space into which the fluid blood trickled by a slow stream through a narrow track.

Case 15.—(Under the charge of Dr. Ronald Gray.)

This was of great interest from several points of view. A man was admitted three days after being wounded by a bullet which entered about the apex of the right posterior triangle and emerged at the back of the shoulder above the posterior margin of the scapula. The entry wound was minimal in size. There was a complete brachial monoplegia. A large, soft, pulsating swelling extended upwards to the level of the top of the thyroid cartilage, raised the sternomastoid slightly,

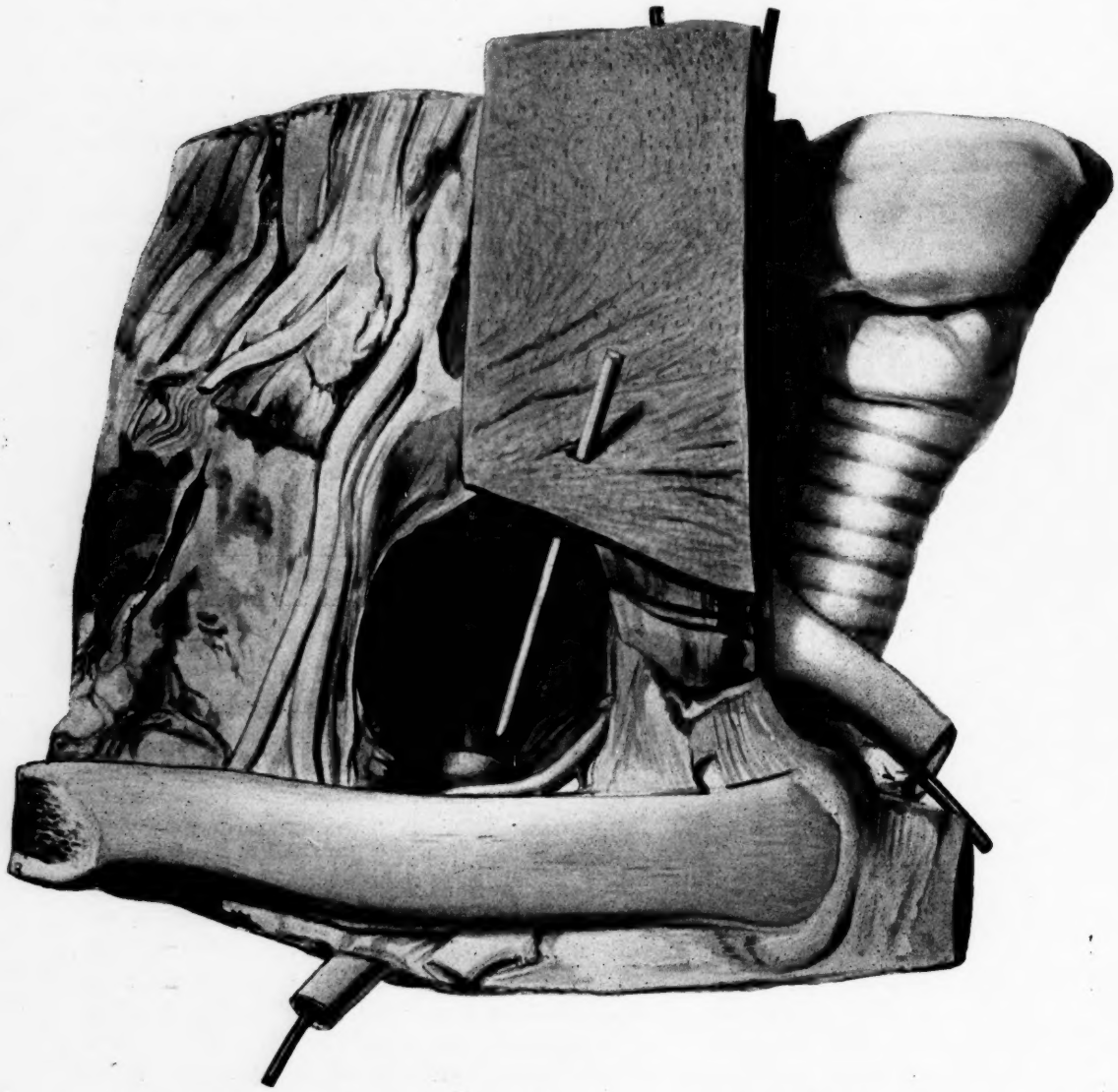


Fig. 132.—Arterial Aneurysm developed in connection with a Complete Division of the Second Portion of the Right Subclavian Artery.

The distal end of the vessel is shown by the dark glass rod. The white rod passes through the original aperture of entrance of the bullet, and indicates its course. The anterior scalene muscle was destroyed in half its width by the bullet. The incision in the sternal portion of the sternomastoid muscle was made for the purpose of applying an arterial clamp to the innominate artery during the progress of the operation on the aneurysm (*Case* 15). (Under the care of Dr. Ronald Gray, No. 7 Stationary Hospital, Boulogne.)

but did not extend beneath the trapezius. The radial pulse was absent. A simple systolic bruit was audible throughout the swelling, but was not widely conducted. The man was very pale and anæmic.

During the next fourteen days complete rest was maintained, and the swelling became much more localized; but on the thirteenth day it was noted to be much softer and apparently increasing. For the latter reasons I decided to operate. As a precaution, the innominate artery was first exposed by an incision along the anterior border of the sternomastoid, and a clamp was placed upon it. An incision was now carried from the lower end of the first one, along the clavicle, and a triangular flap raised outwards. The swelling was then exposed and opened. A cavity containing a greenish fluid, bounded by decolorized lymph, was found completely shut off from the deeper swelling by the deep layers of the cervical fascia. The aneurysm was then opened, a procedure which was followed by an alarming rush of blood, controlled only by pressure downwards and inwards

FIG. 133.—SKIAGRAM SHOWING SIZE, SHAPE, AND POSITION OF A FRAGMENT OF SHELL WHICH WOUNDED THE SECOND PART OF THE RIGHT SUBCLAVIAN ARTERY, GIVING RISE TO AN ARTERIO-VENOUS ANEURYSM.

The resemblance in shape of the fragment to a deformed bullet is of interest (*Case* 19). (Under the care of CAPT. GREAVES, No. 26 General Hospital, Etaples.)

towards the transverse processes of the cervical vertebræ. After some trouble the bleeding, which came from the central end of a complete division of the artery in its second portion, was stopped, and it was thought wiser to tie the first portion of the subclavian trunk when the clamp was removed from the innominate. No trace of the subclavian vein was seen. The patient was much blanched from loss of blood at the end of the operation, and three hours later he died, in spite of a saline infusion.

Fig. 132 shows the condition found at the operation. One point, the destruction of half the width of the anterior scalene muscle, the phrenic nerve lying intact on the fascia at the very edge of the remaining part, is instructive, since had the muscle been divided—as was at one moment contemplated during the difficulties of the operation—the nerve could not have escaped. The

hæmorrhage came from the return flow in the branches of the first and second parts of the artery.

Special points of interest are, firstly, that the space occupied by the original hæmatoma had become loculated and the loculi shut off, while a typical false aneurysm had developed after the manner described in *Part I* of this paper; secondly, that although both the vein and artery had suffered division, a simple arterial aneurysm only developed. I believe this latter to be a far from uncommon result when the vein is completely severed, retraction, thrombosis, and spontaneous closure taking place, while the arterial wound may remain patent. Another example is seen in *Case* 18, already related.

The remaining two cases in the series were both of the arterio-venous variety; both were caused by fragments of shells, and in both, arterio-venous aneurysms resulted, doubtless from partial lesions of the vessels. In neither did any inflammatory change in the clot give rise to anxiety, although the fragments of shell were of some size and were retained; a skiagram showing these in one case is seen in *Fig.* 133. In one, pain and swelling in the upper part of the forearm suggested a small embolism, but no untoward effect followed.

Treatment.—The recital of these cases renders any further remarks on treatment superfluous. The two cases operated upon illustrate well the hazardous nature of the procedure, and the lesson that they are not to be interfered with unless obvious indications exist. In any case, a period of prolonged rest is likely to make an operation easier and safer, and early interference is to be deprecated. Professor Bier, at the meeting of Military Surgeons in Brussels, in 1915, gave an account of a hundred operations for traumatic aneurysms, with eight deaths: it is noteworthy that four of the eight resulted from operations at the root of the neck.

Axillary Vessels.—Fourteen cases of injury to the axillary vessels are included; twelve of these were occasioned by bullets, two by fragments of shells. In two instances there is a record of free primary hæmorrhage, in one of moderate hæmorrhage, and in the remaining eleven it was not severe enough to be recorded.

In five cases it was not possible to determine the actual nature of the lesion, since the only definite sign consisted in absence of the pulse at the wrist, which sign persisted during the whole time the patients were under observation. It is noteworthy that in all five of these cases there was more or less complete paralysis of the upper extremity from concurrent nerve injury.

Five of the lesions were of the right vessels, seven of the left, and in two no record has been kept. In nine cases aneurysms developed, one of the first part, three of the second, and five of the third part of the artery. Five were pure arterial aneurysms, three arterio-venous aneurysms, and one an aneurysmal varix.

The most important and common complication was injury to the brachial nerves; of the whole number of fourteen cases a more or less complete brachial monoplegia was present in nine. It is obvious that the concurrent arterial injury renders the prognosis of the nerve injury very unfavourable, while on the other hand the existence of the primary nerve lesion seriously prejudices

the result to be obtained by surgical treatment of the artery. In this situation, if an operation by suture is practicable, it is specially worthy of consideration.

The other common complication is the co-existence of a hæmothorax; this was present in five out of the fourteen cases, and in view of the fact that the great majority of injuries to the axillary vessels are caused by missiles crossing their course, the proportion seems a moderate one (35·7 per cent).

Case 29, under the care of Capt. Wolfenden, offers some special interest from the point of view of the possibility of the spontaneous cure of a wounded axillary artery, since the swelling, and also a definite arterial bruit after being audible for some four weeks, disappeared completely. As the cessation of the bruit was accompanied by disappearance of the brachial pulse, the occurrence can scarcely be regarded as a satisfactory prognostic sign in a patient the subject of a concurrent brachial monoplegia.

In five of the cases some form of operation was attempted, resulting in the local cure of the aneurysm in four, and death from hæmorrhage in one. A few further remarks may be made on this short series.

In *Case* 28, under the care of Capt. Wolfenden, an early operation was performed on the ground of free primary hæmorrhage followed by a rapidly increasing hæmatoma. A proximal ligature was placed on the third part of the subclavian artery at the field ambulance two hours after the reception of the wound. The operation efficiently controlled the primary hæmorrhage, and prevented the subsequent development of an aneurysm; but the vitality of the limb was seriously endangered, for when the patient arrived at the general hospital, the hand was cold and blue, the forearm swollen and dusky in colour, and the arm was swollen. Common sensation was also absent below the elbow. The limb improved later, but the free part of the thumb, the whole of the little finger, and the tips of the remaining three, became completely gangrenous.

The third part of the subclavian was tied in two other instances, once (*Case* 22) as a preliminary to laying open the sac, and once (*Case* 24) as a curative measure for a false aneurysm of the third portion. In neither instance could the operation be regarded as entirely satisfactory, since in the first, in spite of the precaution, hæmorrhage from the distal end of the wounded vessel was alarmingly free, and the small incision made into the sac had to be rapidly enlarged to obtain control of the bleeding; and in the second a fluid collection of blood persisted for some weeks after the operation, devoid of pulsation, but leaving the limb very stiff and wasted after its absorption.

In the other two cases a local operation was performed; the first, on a false arterial aneurysm, by Capt. Fitzmaurice Kelly, was a success (*Case* 25, and *Fig.* 134); in the second, on an arterio-venous aneurysm, a fatal result followed. The latter operation, performed by myself (*Case* 21), was undertaken on the ground of increase in size of the swelling and thinning of its walls. This case has already been referred to on p. 359. The hæmorrhage was almost entirely venous, and the difficulty in controlling it is there explained. In spite of its amount, the patient left the operating table in fair condition, although very pale. As in the case of subclavian aneurysm (*Case* 15), death occurred from simple anæmia some six hours later. It is worth noting that

FIG. 134.—ARTERIAL ANEURYSM OF THE SECOND PORTION OF THE LEFT AXILLARY ARTERY (*Case* 25, p. 389).

The aperture of entry of the bullet is seen in the outer part of the deltoid region, small and typical. The bullet itself was retained under the small prominences, due to the presence of subjacent blood-clot, seen over the sternum ; note also the ecchymosis in this region. The anterior wall of the axilla projects as a large dome-like cavity. The wrist-drop, due to injury to the musculospiral nerve, is well shown. (Under the care of CAPT. FITZMAURICE KELLY, No. 13 General Hospital, Boulogne.)

throughout the early stage of the operation an attempt was made to control the hæmorrhage by digital compression of the third portion of the subclavian artery, a measure which later events showed to have increased the difficulties in which I found myself. I should perhaps again emphasize what has already been said as to the risks attendant on the treatment of aneurysms at the root of the neck or close below the clavicle, and add that, in spite of the experience of this case, I believe a strictly local operation is the right procedure; and when it is considered safer to secure open control of the third part of the subclavian artery, this should be maintained by an arterial clamp, or a temporary ligature.

Brachial Vessels.—This series contains only eleven cases, a very small number considering the frequency with which these vessels are wounded. The small number included in my record depends on the fact that such injuries are very easily treated, that the vessel is often ligatured primarily, and that in consequence of their minor importance, cases come comparatively rarely under the observation of the consulting surgeon. On the other hand, the series includes a surprising number of bad results, especially in the occurrence of gangrene, a complication hardly to be expected in dealing with wounds of these vessels.

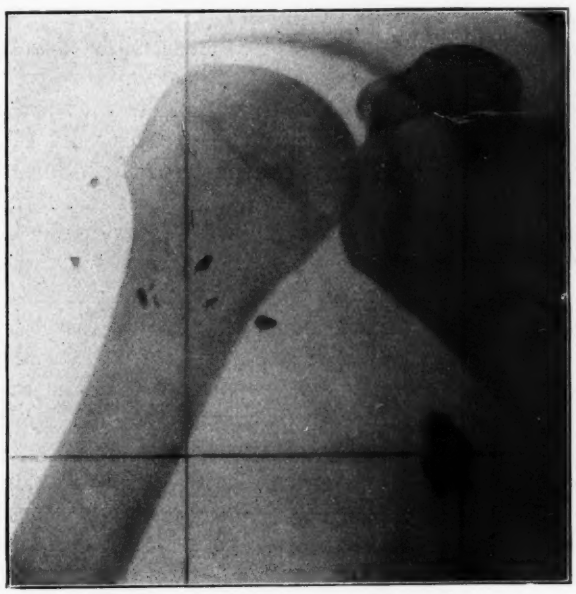


FIG. 135.—SKIAGRAM SHOWING FRAGMENT OF SHELL ON CHEST WALL, AND SMALLER FRAGMENTS IN ENTRY END OF WOUND TRACK, WHICH GAVE RISE TO THE DEVELOPMENT OF AN ANEURYSMAL VARIX IN THE THIRD PART OF THE RIGHT AXILLARY ARTERY. (*Case* 26.) (Under the care of CAPT. GREAVES, No. 26 General Hospital, Etaples.)

Of four cases of simple ligature complicated by fractures of the humerus, gangrene occurred in three. In one of these, probably a tourniquet left in position for sixteen hours was to blame, and very severe primary hæmorrhage in another. In a fifth case the wound in the vessel apparently healed without any complication, in a similar manner to those of the axillary artery mentioned above.

In five cases an arterial false aneurysm developed, all of which were treated by direct ligature; in one gangrene followed. One aneurysmal varix is included, but no arterio-venous aneurysm. In one instance (*Case* 34) of wound of both artery and vein, the opening in the latter was closed by a fragment of shell which projected into the cavity of the vessel. The tendency of the completely divided brachial artery to thrombose and heal spontaneously is well known.

Radial and Ulnar Vessels.—One arterio-venous aneurysm of the ulnar, one of the radial, and one arterial false aneurysm, complete the whole series,

obviously enormously out of proportion to the number of vessels which must have been wounded. None the less, traumatic aneurysms of these vessels are rare, doubtless on account of their small size, and the frequency with which they suffer complete division.

Femoral Vessels.—The number of injuries and aneurysms included amounts to nearly half the whole series, a proportion corresponding with the length and size of the vessels. Of the thirty-six aneurysms, fifteen were of the common femoral, seven of the superficial femoral in the middle part of its course, and nine were situated in the lower third of the artery. The frequent occurrence of wounds of the vessel in Scarpa's triangle is no doubt due to its exposed position, while the fixation of the artery in the lower third renders escape of the vessel almost impossible if a bullet crosses its course. In the middle third the main trunk is comparatively movable, and is only in special danger at the points from which lateral branches are given off. The mobility of the femoral artery in the greater part of its course exerts a considerable influence on the exact character of the wounds; thus we find amongst twenty-three cases operated upon in which direct observation was possible, that in seventeen the wound was lateral, in one the lateral wound involved more than two-thirds of the calibre, and hence was comparable to a complete division, in four the vessels were completely severed, and in only one instance was the artery perforated. The perforation occurred in the most fixed portion of the vessel at the extreme limit of Hunter's canal (the adductor canal).

Of the twenty-six cases in which the nature of the missile was certain, in nineteen the wounds were produced by bullets, in five by fragments of shell, and in two by shrapnel balls.

In the whole series of thirty-six cases, primary hæmorrhage is noted to have been free in nine, while secondary hæmorrhage occurred in six instances. Gangrene of the limb was met with seven times.

Arterial hæmatomata or false aneurysms developed in twenty-three cases, arterio-venous aneurysms in six, and aneurysmal varices in five.

Femoral aneurysms exhibit in a marked degree the tendency to localization common to all traumatic aneurysms; but, on the other hand, the anatomical construction of the limb, and especially the width and length of the vascular cleft, favour the development of very extensive primary extravasations of blood. In Scarpa's triangle such extravasations are very superficial, they are usually attended by extensive ecchymoses, and from the want of support by the surrounding structures they tend to be large and soft, and to coagulate later than is the case elsewhere in the limb. Hence, if they are co-existent with a septic wound, especially a large 'explosive' exit in the buttock, the danger of secondary hæmorrhage is greater than it is in extravasations at a lower level. Over such superficial hæmatomata the nature of the wound of entrance is often very characteristic. As the effused blood contracts and undergoes absorption, the small closed wound with its circumferential area of thickening tends to project from the surface as a small papule with a depressed centre. Such a wound is shown in *Fig.* 136, *Case* 55, where the appearance has been very admirably depicted by the artist, Mr. Maxwell. A similar prominence of the wound may be met with in other parts of the body, but is more common in this region than elsewhere. In the lower part

FIG. 136.—ORIFICE OF ENTRY OF A BULLET WHICH CAUSED A COMMON FEMORAL ARTERIO-VENOUS ANEURYSM (*Case* 55).

The minimal size of the aneurysm can be appreciated by regarding the outline of the groin. The cutaneous ecchymosis over the adductor region still persists, while the papular form of the orifice of entry, with its central depression, so characteristic of such wounds during the process of absorption and contraction of the underlying blood-clot, is well shown. (Under the care of CAPT. MARTIN, No. 7 Stationary Hospital, Boulogne.)

of the course of the artery, the blood effusion gives rise to a tense fusiform enlargement of the whole limb; the blood not only collects in the line of the vascular cleft, but when the wound extends from front to back of the limb, the primary effusion passes through the opening in the adductor muscles, and may collect in very large quantity in the posterior compartment of the thigh; or when the vessel is wounded in the adductor canal the effusion continues into the popliteal space. The fact that these extensions commonly take no part in the persisting false aneurysm has already been sufficiently dwelt upon in *Part I* of this article. The extension in three cases of wound of the profunda is worth noting as being identical. In each the vessel was wounded near its origin, and in two cases completely severed. The blood effusion in all extended upwards into Scarpa's triangle, and did not pass below the middle of the thigh; hence a wound of the common femoral was diagnosed. A similar course was taken by an effusion from the internal circumflex artery.

Gangrene was met with in five cases (13·8 per cent), in all of which operations were performed; twice it had commenced before the artery was ligatured, once the patient was suffering from the condition known as 'trench foot' in both extremities, once it followed upon two severe secondary hæmorrhages in a patient dying from septicæmia, and once it only involved the toes. In one case only it followed the operation of ligature, on the sixth day. In all five instances the patients were the subjects of severe wound infection.

Secondary hæmorrhage was four times an indication for operation, and it followed operations on three occasions, in each leading to a fatal issue.

Operations, consisting without exception of ligature of the artery above and below the wound, were performed in twenty-five of the cases included. The common femoral was the seat of ligature in five (two deaths), the superficial femoral in seventeen (three deaths), the profunda in two (one death), and the internal circumflex in one. There were, therefore, six deaths, a mortality of 24 per cent. In no instance did secondary hæmorrhage occur from the point of ligature of the trunk.

Sixteen of the operations were performed for the treatment of arterial hæmatomata or false aneurysms. The indications for operation were in eight cases infection of the accompanying wounds of the soft parts; in one, extension of the hæmatoma; in two, secondary hæmorrhage; and in two, impending gangrene. The remaining four were operated upon as suitable cases for ligature. Three of the sixteen died, in each instance as a result of secondary hæmorrhage from small branches in the depth of a septic wound of the thigh. In all but one of the cases the lesion of the artery consisted in a lateral wound; in several the vein was thrombosed as a result of contusion.

In one case of solid arterial hæmatoma due to complete severance of the vessels, not included in the above numbers, gangrene of the foot and leg was pronounced on the fourth day, and amputation was performed.

In only six of the thirty-six cases did arterio-venous aneurysms develop; two of these were of the common femoral, and neither patient was in a condition suitable for operation when he left the country; four were in connection with the middle part of the superficial femoral vessels. No special point needs to be emphasized regarding patients transferred without being subjected to opera-

tion. Of the three operated upon, one had already developed a serious infection of an explosive exit wound in the buttock, and the foot and lower third of the leg were gangrenous. It appeared preferable under these conditions to deal directly with the wounded artery, rather than to perform a high amputation which would still have a septic wound-track at its base. The operation was performed on the fourth day after the reception of the wound, and two days later the patient died of toxic infection dependent on an acute gaseous cellulitis of the buttock in connection with the original bullet track.

The second case was of interest mainly from the fact that the vein had suffered complete division, and the central end was thrombosed. The arterio-venous communication was between a small lateral wound of the artery and the open end of the distal portion of the vein. The indication for the operation was impending gangrene of the foot, and the operation was so

FIG. 137.—SKIAGRAM SHOWING A RETAINED SHRAPNEL BALL IN THE ADDUCTOR REGION OF THE LEFT THIGH WHICH HAD WOUNDED THE VESSELS AND GIVEN RISE TO A COMMON FEMORAL ARTERIO-VENOUS ANEURYSM. (*Case* 67.) (Under the care of CAPT. GREAVES, No. 26 General Hospital, Etaples.)

far successful as to limit the eventual gangrene to the sole. Mr. Lawford Knaggs wrote me some months later that the foot was still in jeopardy. It should be added that a condition of slight 'trench foot' was existent in the sounder limb.

The third case formed an excellent example of the difficulties attendant on some injuries to the femoral vessels in the middle part of the thigh. Ligature of the main trunk had but little influence on the hæmorrhage, which continued from many points after the vessel had been occluded. It became necessary to leave a number of forcipressure forceps in the wound, and to plug it, to prevent a hopeless degree of anæmia. The patient did well, and the aneurysm was cured.

The five cases of aneurysmal varix offer little scope for comment, since the signs were typical, and no unpleasant symptoms accompanied the

condition. Two were operated upon, the development in one being accompanied by a moderately severe anaerobic infection necessitating primary incisions. The operation on the vessels was done on the seventy-third day, a small lateral opening in the artery and a greatly dilated vein being dealt with. A second large vein, probably a dilated great anastomotic branch, lay side by side with the femoral vein at the site of the communication at the lower end of Hunter's canal.

The second case (*Case* 64) was operated upon on the sixteenth day, and is worth brief recital as illustrating a not uncommon difficulty in dealing with this condition. The position of the wounds, and the loudness and high pitch of the murmur, apparently indicated the level of the communication to be about the centre of Hunter's canal. The vessels were freely exposed, but no dilatation nor any 'shivering' of the vein was discovered. The thrill could be controlled by a clamp at the upper limit of the wound; but in spite of a somewhat free separation of the vessels, I failed to locate the point of communication. The wound was therefore closed, and the patient sent home. During the succeeding five months this patient was in various hospitals in England, and then returned to his depot at Winchester for light duty. He was thence transferred to the Royal Hampshire County Hospital, suffering with pain and swelling of the limb. Mr. Godwin, under whose care he came, has kindly furnished the following note of the operation he performed. The account is of special interest, as the vessels were repaired successfully by suture, and also because the difficulty experienced at the primary operation is shown to have depended merely on a faulty localization of the point of injury.

On admission, the right leg was slightly swollen and œdematous. On palpation a very distinct thrill was discernible over the whole of the inner side of the thigh and popliteal region, and a very loud, harsh, roaring bruit was heard all over the femoral and popliteal vessels. The patient was kept at rest for two weeks, and as there was no improvement it was decided to operate.

Operation.—An elongated internal incision was made in the line of the adductor magnus tendon, giving enough room to allow of control of the femoral and popliteal arteries. On exposing the vessels, it was found that the communication between the artery and vein was just below the opening in the adductor magnus tendon.

The vessels were carefully dissected out. The vein was somewhat dilated, and there was quite a small sac between the artery and vein.

Crile's clamps were applied to the vessels and to a branch of the artery, which was taken to be the internal articular branch, coming off just opposite the hole in the artery. The sac was dissected off. The hole in the vein was found to be larger than that in the artery. After cutting away about half an inch of the vein, an end-to-end anastomosis was done with fine silk sutures under sterilized paraffin and saline without any undue tension on the vessel. It was not possible to do an end-to-end anastomosis of the artery, so the edges in the hole of the vessel were refreshed, and the artery was closed laterally with fine silk sutures, and a graft from the internal saphenous vein was sewn over the sutured vessel, with the suture line on the opposite side. On removing the clamps the circulation was perfect, and there was no hæmorrhage from the stitched vessels. The wound was closed, and the limb was put on a back splint slightly flexed. Healing by primary union occurred, and the stitches were removed on the tenth day. The operation lasted two hours.

After-treatment.—Gentle massage and movements. There was never any swelling or œdema of the leg after the operation, and when seen five months later, the circulation was normal and the patient doing light duty.

Two of the three cases of injury to the profunda are worthy of quotation for several reasons, such as the size attained by the hæmatoma, the uncertainty of the diagnosis, the difficulty experienced in controlling the hæmorrhage at the time of operation, and the fact that both operations were followed by a fatal result.

Case 69.—(Under the care of Capt. Oliver.)
A man was admitted with a shell wound of the thigh, one and a quarter by one inch in size, three inches below the mid point of Poupart's ligament, and apparently superficial in nature. The wound was fairly clean on admission, there was some swelling of the thigh, no pulsation, and the tibial pulses were normal.

Two days later there was a marked increase in anæmia, associated with great increase in the size of the thigh, and the development of pulsation and a systolic bruit. The swelling extended from the level of the anterior superior spine to the middle of the thigh. A temporary elastic ligature was applied to the common femoral artery, the swelling was incised, and two pints of clot were evacuated. A lateral wound was discovered on the outer side of the origin of the deep femoral artery; a ligature was applied below this, and the common femoral artery definitely closed also. After four days' satisfactory progress, gangrene of the toes set in, and a few days later the man succumbed to a general toxæmia.

Case 71.—(Under the care of Capt. Max Page.)
A man was admitted with two wounds, one penetrating the right chest, the second traversing the buttocks and wounding the rectum. A large hæmatoma was present in Scarpa's triangle. During the following week the temperature rose (reaching 103°), with occasional rigors, and the hæmatoma showed signs of breaking down.

Under spinal anæsthesia the suppurating hæmatoma was incised; it extended deeply through the obturator foramen, and the common femoral vessels were felt pulsating in its anterior wall. On the same night a severe secondary hæmorrhage took place; this was controlled by placing a ligature on the common femoral artery, but the patient died a few hours later.

A subsequent examination of the limb showed the deep femoral artery to have been completely severed at its origin from the common femoral. It had no doubt been thrombosed, but the clot had given way as a result of secondary infection.

Case 72.—(Under the care of Capt. Oliver.)
In this case the internal circumflex branch only was wounded. A large hæmatoma was found as in the previous case, unaccompanied by the presence of either pulsation or bruit. The posterior tibial pulse was ablated, and the whole thigh was white and tense. Softened clot commenced to escape from the wound of entry, and on the eleventh day the opening in the front of the thigh was enlarged, a great quantity of clot evacuated, and an opening discovered in the internal circumflex artery close to its origin. The man made an uninterrupted recovery.

General Consideration of the Treatment of Femoral Aneurysm. — The indications for active treatment in the early stages have been already set forth in the foregoing pages; they consist in (1) Spreading infection of the surrounding tissues; (2) Extension of the blood effusion, or external secondary hæmorrhage; (3) Threatening gangrene of the limb; and (4) The rare event of acute infection of the hæmatoma itself.

Under other circumstances, rest to the limb and an expectant attitude should be maintained for a fortnight or three weeks, and this course is not to be deviated from on account of a local septic state of the wound in the soft parts; for while the clot bounding the hæmatoma rarely gives way, the wound

made for the operation on the artery cannot be kept free from infection. Unfortunately I am not in a position to be able to quote numbers as to the frequency with which gangrene follows a primary ligature of the vessel; but I know it to be common, and have been told of several instances. Beyond this, few successful cases of primary ligature of the femoral vessels reach the general hospitals.

Certain conditions special to operations in the thigh may be shortly considered.

1. Condition of the tibial pulses as an indication for operation. The presence of the tibial pulses at the ankle, regarded as an indication of the persistence of a column of blood circulating in the main vessel, must always be of importance; but in the early stages it is no evidence of an enlarged collateral circulation, for when existent it is promptly extinguished by ligature of the femoral trunk, and only in two instances did it reappear during the average period of fourteen days during which the patients remained under observation. On the other hand, the disappearance of an existing tibial pulse while the patient is under observation is a serious sign of increasing vascular obstruction, especially if this be contemporaneous with the cessation of the arterial murmur and with hardening of the aneurysmal swelling. Under these circumstances an operation is imperative, and may save the vitality of the limb, stave off impending gangrene, or even cause a recession in the line of advance in an already gangrenous limb.

2. What influence does simultaneous ligature of the vein exert on the after-history of these operations? I believe that it is of no immediate detriment; I have myself ligatured both vessels on two occasions for arterial aneurysms, and have seen it done three times. Beyond this, it is a necessary procedure in cases of arterio-venous aneurysm if ligature and excision be the operation chosen, and it has not proved dangerous. Further, in many cases of arterial wound, the bullet has contused the neighbouring vein and caused thrombosis, and here again no immediate ill effect appears to be seen in the results of arterial ligature. As to the permanent effect on the general nutrition of the limb, it is too early to speak.

3. What is the effect of arterial ligature on threatening or early gangrene? It has not proved of such marked benefit as might be inferred from the reports of isolated cases. It is most satisfactory in those cases where the pressure of large blood effusions or of hard, clotted extravasations on the collateral circulation can be relieved. It may be added that in a few cases in which the operation has been done in the absence of large extravasations, it certainly has not acted hurtfully.

4. Two practical points are worth reiterating:—

i. These operations are without doubt most safely performed with the aid of an Esmarch's tourniquet. If the application of this be impracticable, a temporary ligature of the common femoral or external iliac artery is advisable, or they should be exposed, and the lumen occluded by the application of an arterial clamp. When the blood effusion extends freely beneath Poupart's ligament, and an incision for the external iliac is dangerous, the abdominal aorta should be controlled by a drainage tube tourniquet tied round the waist. For this last resource I am indebted to Capt. Wolfenden,

who so controlled the aorta during a ligature of the common femoral which he helped me to perform.

The precaution of employing a tourniquet is not advised merely for the control of bleeding from the main vessel, which can usually be readily maintained by digital pressure. The main trouble in stopping the hæmorrhage lies rather in the difficulty of securing the wounded branches in the large cavity in the thigh, this difficulty being most marked when the branches of the profunda are those concerned.

ii. In dealing with large hæmatomata in the middle part of the thigh, it is well to remember that the mobile vessels have travelled in the direction of least resistance, i.e., away from the femur, and that they will probably be found in the inner wall of the cavity, and not upon its floor.

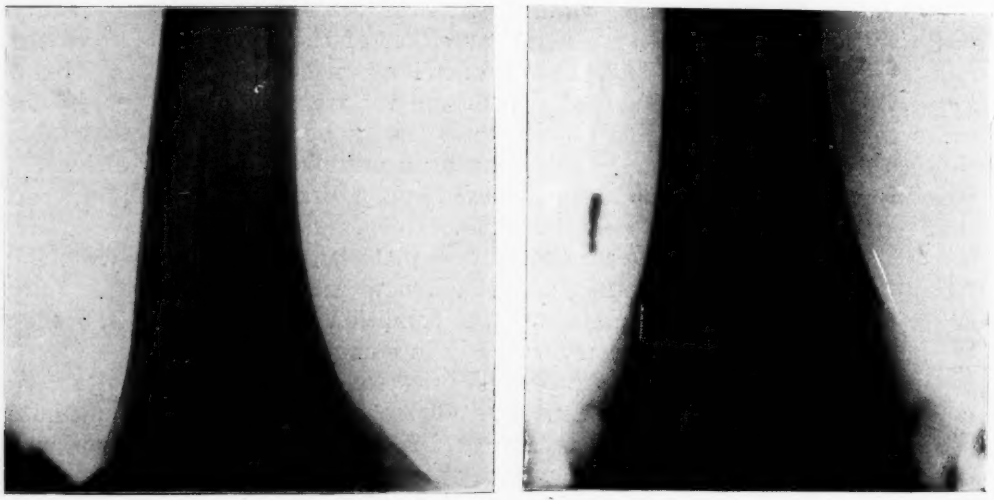
As far as the experience gained by observation of cases recently operated upon goes, ligature of the common femoral artery appears to seriously compromise the subsequent general nutrition of the limb, apart from the risks of actual gangrene. This vessel is one for wounds of which suture should, if possible, be attempted, so as to maintain the viability of the trunk. In order to attain this desirable object, cases should be allowed a considerable time to finally settle down. Under existing conditions almost any aneurysm which arrives in England is at once treated by ligature, even when the surgeon in France has considered that the chances of spontaneous cure were fair. This is obviously a class of case that suffers materially from passing from the hands of one surgeon to another, when each new medical attendant is fully acquainted neither with the stage of the condition at a prior date, nor with the opinion held by the surgeon previously in charge of the patient.

Popliteal Vessels.—The series of injuries involving the popliteal artery and vein is small. It is also the most unsatisfactory with regard to immediate results or the effect of operative treatment, that is dealt with in this communication. It is not possible to determine with certainty whether the series is in any way representative of this class of injury as a whole, since it is clear that many patients suffering with small type bullet wounds traversing the popliteal space are not infrequently regarded as trivial cases and promptly transferred home without exhaustive examination. This source of fallacy is not however confined to wounds in this area, and reasons exist for regarding injuries to the popliteal space as especially dangerous to the vitality of the limb. Such are: (1) The depth of the popliteal space, and the resistant character of its walls; (2) The constriction exercised on the main trunks by the fibrous and bony structures bounding their points of entry and exit into and from the space; (3) The fixation and relative incapacity for rapid dilatation of the collateral branches which arise from them; and (4) The fact that patients with wounds in this area are apt to maintain the knee in a position of flexion, in which the circulation through the main trunks is more seriously interfered with than in most other situations. Be this as it may, the fact remains that of sixteen injuries to the popliteal vessels here included, the limb had to be amputated in eight, and this in spite of the fact that the wounds of the soft parts were in no case serious.

In only eight of the cases were aneurysms developed, six arterial and two arterio-venous. The remaining eight patients were dealt with during the

wounded artery stage. In eight cases the wounds were caused by bullets, in four by shell fragments, and in four the nature of the projectile is not known.

The nature of the wound in the artery was lateral in seven, a complete severance in four, a perforation in one, and unknown in three. In one case the lesion consisted in perforation of the vein and thrombosis of the artery (see *Fig.* 121, p. 355). In two instances a lateral wound of the artery was accompanied by complete division of the vein, and in two by venous thrombosis. These details show the injuries to have been generally of a severe class. In four cases a hæmarthrosis of the knee was present, and five were complicated by the co-existence of fractures.



FIGS. 138, 139.—SKIAGRAMS SHOWING THE POSITION, SHAPE, AND SIZE OF A FRAGMENT OF SHELL WHICH HAD WOUNDED THE POPLITEAL ARTERY AND GIVEN RISE TO THE FORMATION OF AN ARTERIAL ANEURYSM (*Case* 78). (Under the care of CAPT. GREAVES, No. 26 General Hospital, Etaples.)

The complication which eventually demanded amputation in nine of the sixteen cases was gangrene; in eight of these the gangrene was primary, in one only did it follow ligature of the artery. The artery was ligatured in seven cases in the hope of arresting or causing recession of impending gangrene; this procedure failed in all but three cases. In one impending gangrene was averted, in a second it was limited to the tip of the great toe, and in a third to the anterior half of the foot; there is little doubt that in all three the procedure was successful. In the other four a secondary amputation was necessary.

The literature of the Manchurian war, especially the writings of Zoege von Manteuffel, aroused great hopes of successfully treating early or impending gangrene arising from injury to the popliteal vessels by prompt ligature. It was suggested that in this position, especially, the relief of pressure by blood-clot on the collaterals would greatly improve the peripheral circulation. This

small series of operations is therefore disappointing; but it must be added that in none of the cases dealt with did much pressure by clot exist, in the majority there was none, and in the only case in which it was a prominent element an amputation was unavoidable by reason of the stage the gangrene had already reached.

Only four of the whole series escaped gangrene, two treated expectantly—one arterial, one arterio-venous—and two treated by ligature. In the first of

FIG. 140.—SKIAGRAM SHOWING THE BONES OF THE THIGH AND LEG OPPOSITE THE POPLITEAL SPACE (*Case* 108).

An impacted bullet is seen lying transversely in the popliteal space, the point of which, after traversing the popliteal vein, lodged in the popliteal artery without penetrating the anterior wall. Removal of the bullet some days after its entrance was followed by free hæmorrhage, necessitating ligature of both vessels. (Under the care of MAJOR STONEY ARCHER, No. 5 General Hospital, Angers.)

the two latter, gangrene was impending, while the second was the simple perforation illustrated in *Fig.* 140.

Secondary hæmorrhage was met with once only, and was followed by gangrene demanding amputation of the leg.

With regard to the question of the danger of simultaneous ligature of the artery and vein, it may be added that this was done in one of the successful cases. In two others the vein was completely severed and the proximal end thrombosed, and in two the intact vein was thrombosed. The case of arterial

contusion and thrombosis accompanying the divided vein has been already referred to (p. 355).

Posterior Tibial Vessels.—Injuries to the vessels in the calf, and also of the anterior tibial artery, have been very common, and a certain number of aneurysms have been met with. As a rule the results have either been of small importance, or the aneurysms have been promptly dealt with, hence my attention has been drawn to very few of the cases by the officers in charge.

Only three cases appear in the general table; and these do so, because from them were derived the three small arterial sacs which have served so useful a purpose in the description of the development of false aneurysms. (See *Fig.* 124.)

TABLE OF ARTERIAL OR ARTERIO-VENOUS

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondary Hæmorrhage: Date
INNOMINATE.						
1	Major Steel	No information	Small slit entry over left sternoclavicular articulation. No history of pain. Hæmorrhage	—	? Varix	None
CAROTID.						
2	Capt. Kelly	Bullet	Type. Profuse primary hæmorrhage	Upper third right common carotid	Arterial	None
3	Lt.-Col. Watson	Bullet	Type. No history of primary hæmorrhage	Right common carotid	Aneurysmal varix	None
4	Major Parsons	Bullet	Type. No history of primary hæmorrhage	Left common, middle third	Varix	None
5	Major Shea	Bullet	Type. No history of primary hæmorrhage	About centre of left common carotid	Varix	None
6	Lt.-Col. Butler	Shell	No history of primary hæmorrhage	Right common carotid	Arterio-venous aneurysm	Fourth day
7	Dr. Ronald Gray	Bullet	Slit in posterior triangle, margin of trapezius. Considerable primary hæmorrhage	Right common carotid	Arterio-venous aneurysm	None
8	Capt. Oliver	Bullet	Type. No history of primary hæmorrhage	Right common carotid	Varix	Tenth day: ½ pint

I must not close this paper without expressing my warmest appreciation of the kindness of the many medical officers under whose charge the whole series of cases were observed by me, and who took every opportunity of aiding me in the investigation of the patients. To them I owe much, and I take this occasion of offering my sincere thanks. I am also much indebted to my friend and A.D.C., Lieut. L. W. Shelley, for his constant help in the recording and arrangement of the cases.

Lastly, I am further much indebted to Mr. Beadles for his beautiful dissections, and to Messrs. Maxwell and Sewell who have drawn the illustrations.

ANEURYSMS AND ANEURYSMAL VARICES.

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
—	Complete rest	Transferred	No murmur noticed before eleventh day. Chest examined by competent observer. Right radial pulse weak
See notes	Common carotid tied below omohyoid eleventh day	Transferred	Cerebral embolism. Hemiplegia fifteenth day. Slight improvement of paralytic symptoms when transferred to England. See text, p. 382
—	Complete rest	Transferred	Slight thrill right side. Definite soft double murmur. No pulsating tumour
—	Complete rest	Died	Death due to concurrent injury to head. See text, p. 372, and illustration, *Fig.* 127
—	Complete rest	Transferred	Typical double murmur and thrill. Noise of murmur bothered him at first, not noticed at end of ten days
See notes	—	Died	Death sudden. Hemiplegia. Large retropharyngeal and retro-œsophageal space due to gaseous cellulitis. See text, p. 379
—	Complete rest	Transferred	Bullet retained beneath skin above centre of left clavicle. Much ecchymosis of left shoulder. Circumflex nerve affected slightly. Voice hoarse at first, now normal. Murmur conveyed to heart. Tumour of considerable size
—	Complete rest	Died	Laryngeal paralysis. P.M.—Lungs full of blood. See text, p. 380

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VENOUS

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondary Hæmorrhage: Date
CAROTID—*continued*.						
9	Lt.-Col. Butler	Shell	Type. No history of primary hæmorrhage	Left common carotid upper third	Varix	None
10	Major Shea	Shell	Slit level of top of thyroid cartilage. Free primary hæmorrhage	Right external carotid	Varix	None
11	Capt. Clementi Smith	Shell	Small slit. Shrapnel retained. Profuse primary hæmorrhage	Left external carotid	Varix	None
12	Major Davies-Colley	? Shell	Small incised, ant. margin of left sternomastoid at level of angle of jaw. No history of primary hæm.	Upper third left common carotid	Arterio-venous aneurysm	None
13	Capt. Max Page	? Bullet	Type. No history of primary hæmorrhage	Right internal carotid	Arterial	None
THYROID VESSELS.						
14	Capt. Mumford	Bullet	Wound of tip of nose and upper lip. Bullet not localized. No history of primary hæmorrhage	Thyroid vessels	Arterial	Third day
SUBCLAVIAN.						
15	Dr. Ronald Gray	Bullet	Type. Severe primary hæmorrhage	Second portion right	Arterial	None
16	Lt.-Col. Butler	Bullet	Type. No history of primary hæmorrhage	First part left	Arterial	None
17	Lt.-Col. Butler	Bullet	Type. No history of primary hæmorrhage	Third part right	Arterial	None
18	Lt.-Col. Gordon Watson	Shell	Middle of posterior triangle. No history of primary hæmorrhage	Second part left	Arterial	Free, twelfth and fourteenth days
19	Capt. Greaves	Hand Grenade	Ragged wound 1½ in. long above clavicle over anterior border of sternomastoid. No history of primary hæmorrhage	Second part right	Arterio-venous aneurysm	None
20	Capt. Greaves	Shell	Right side middle of anterior border of trapezius. No history of primary hæmorrhage.	Third part right	Arterio-venous aneurysm	None

ANEURYSMS AND ANEURYSMAL VARICES—*continued.*

O-VENOUS	SECONDARY HÆMORRHAGE: DATE	GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
	None	—	Complete rest	Transferred	Loud deep double murmur below wound. Two days later systolic elements of a loud, 'slamming' character, conducted to left subclavian artery
	None	—	Complete rest	Transferred	Double murmur, systolic element traceable to heart (*Fig.* 131, p. 383)
	None	—	Complete rest	Transferred	Typical double murmur. Systolic element most marked over wound, roar below. First cervical transverse process chipped
	None	See notes	Complete rest	Transferred	Complete aphasia. Pupils, R < L. Left palpebral fissure small. No difference in sweating. Embolism (cerebral). See text, p. 358
	None	—	Common carotid tied about fifth day	Cured	Had tense swelling of soft palate and right side of pharynx, which gradually disappeared after ligature of common carotid. No cerebral symptoms. Right facial weakness (? peripheral). See text, p. 378
	hird day	None	Complete rest	Died	On third day two severe attacks of dyspnœa, in second of which man died. Much fullness of right side of neck. No wound of great vessels, but left half of thyroid ploughed up, and large blood cavity See text, p. 382
	None	None	Ligature second part fourteenth day	Died	See text, p. 383
	None	Moist, from fingers to middle of hand	Amputation at middle of forearm	Transferred	Arterial bruit. No aneurysm detected. Large hæmothorax, which suppurated. Embolism of brachial artery. See text, p. 358
	None	None	Complete rest	Transferred	Right hæmothorax. See text, p. 385
	e, twelfth d fourth days	None	Division of sternomastoid, exposing junction of subclavian and internal jugular vein. Sac opened by removal of plugs. Replugged. Free hæmorrhage	Died	P.M.—Pus in posterior mediastinum. All tissues stiff and infiltrated, even in anterior mediastinum. See text, p. 335
	None	None	Complete rest	Transferred	Typical murmur, conveyed to both sides of neck, audible over whole præcordium. Large swelling. Weakness of upper extremity
	None	None	Complete rest	Transferred	Had pain in forearm and local swelling; ? embolism

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VENOUS

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondary Hæmorrhage: Date
AXILLARY.						
21	Capt. Bradford	Bullet	Moderately severe primary hæmorrhage	First part left	Arterio-venous aneurysm	Secondary extension
22	Lt.-Col. Butler	Bullet	Entry wound slit midway between middle of clavicle and ant. axillary fold. Exit wound circular over fifth dorsal spine. No history of primary hæm.	Second part left	Arterial	Secondary extension
23	Major Sinclair	Bullet	Type entry and exit. No primary hæmorrhage	Third part left	Arterio-venous aneurysm	None
24	Capt. Martin	Bullet	Type entry and exit. Large primary hæmorrhage	Third part left	Arterial	None
25	Capt. Kelly	Bullet	Entry wound 4 in. below spine of scapula. Bullet retained over sternum. No history of prim. hæm.	Second part left	Arterial	None
26	Capt. Greaves	Shell	Entry wound slightly excavated. Circular. Considerable primary hæmorrhage	Third part right	Varix	None
27	Capt. Burrows	Shell	Large gaping wound left scapular region. No history of primary hæmorrhage	Second part	Arterio-venous aneurysm	None
28	Capt. Wolfenden	Bullet	Primary hæmorrhage in free gushes. Hæmatoma in axilla and on chest wall	Third part left	Arterial	None
29	Capt. Wolfenden	Bullet	Entry slit above centre of right clavicle. Exit vertical border right scapula. No primary hæmorrhage	Third part right	Arterial	None
BRACHIAL.						
30	Capt. Rahili	Shell	Wound from posterior triangle to axilla. Free primary hæmorrhage	Upper third left	Arterial	None
31	Lt.-Col. Butler	Shell	No history of primary hæmorrhage	Lower third left	Arterial	Secondary hæmorrhage
32	Dr. Graham Jones	Bullet	Explosive wound of forearm. No history of primary hæmorrhage	Lower third right	Arterial	None

ANEURYSMS AND ANEURYSMAL VARICES—*continued.*

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
None	Operation twenty-fourth day. Division of pectorals. Severe hæmorrhage. Ligature of artery and vein.	Died	See text, p. 389
None	Third part of subclavian tied, then axillary in third part, on seventeenth day	Cured	Free hæmorrhage after tying subclavian (third part) until third part of axillary tied. Suppuration occurred in axilla, which cleared up under treatment. No radial pulse returned
None	Complete rest	Transferred	Seventh day murmur became louder and higher pitched. Hæmothorax. Brachial monoplegia
None	Complete rest	Transferred	Hæmothorax. Operation, third part of subclavian tied in England. After operation fluid blood in sac persisted for some weeks
None	Operation twenty-fifth day. Sac opened and artery ligatured above and below opening	Transferred	Brachial monoplegia. See text, p. 389, and illustration, *Fig.* 134, p. 390
None	Complete rest	Transferred	Œdema of upper limb probably due to tourniquet. Ulnar anæsthesia
None	Complete rest	Transferred	Murmur and swelling gradually diminished
Little finger and free part of thumb and last joints of remaining fingers	Primary proximal ligature two hours after wound	Transferred	Brachial monoplegia. See text, p. 389
None	Complete rest	Transferred	Brachial monoplegia and hæmothorax. Systolic bruit disappeared, also swelling (? spontaneous cure)
None	Double ligature	Cured	Aneurysm size of tangerine orange. Median nerve appeared uninjured at operation, although loss of function existed
Gangrene of hand	Ligature of brachial	Cured	Amputation mid-forearm
None	Double ligature of brachial	Cured	Two-thirds division of artery, with retraction of open ends three-quarters of an inch

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VENOUS

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondary Hæmorrhage: Date
BRACHIAL—*continued.*						
33	Lt.-Col. Gordon Watson	Bullet	Wound of thumb. Bullet passed up forearm to above elbow. Considerable primary hæmorrhage	Lower third left	Arterial	None
34	Capt. Martin	Shell	No history of primary hæmorrhage	Middle third right	Arterial	None
35	—	Bullet	Type wounds. No history of primary hæmorrhage	Right	Varix	None
ULNAR.						
36	Lt.-Col. Gordon Watson	Shell	Entry wound small, perforating upper third close to inner border of ulna. Exit wound large, ragged, 1 in. long, middle and lower third flexor surface of forearm ulnar side. No history of primary hæmorrhage	Left	Arterio-venous aneurysm	Twice. First on eleventh day, second on twelfth day
RADIAL.						
37	Capt. Rankin	Shell	Dorsum of hand	Right	Arterio-venous aneurysm	—
FEMORAL.						
38	Major Littler Jones	Bullet	Type wounds. No history of primary hæmorrhage	Lower third rt. superficial fem.	Arterial	None
39	Capt. Stanley Raw	Shell	Small entry wound inner side of thigh. No history of primary hæmorrhage	Middle third rt. superficial fem.	Arterial	None
40	Lt.-Col. Gordon Watson	Bullet	Type wounds. No history of primary hæmorrhage	Middle third rt. superficial fem.	Arterial	Sec. hæm. tenth day
41	Major Littler Jones	Bullet	Type wound. Large primary hæmorrhage	Lower third superficial fem.	Arterial	None
42	Lt.-Col. Butler	No information	No primary hæmorrhage	Superficial fem. lower third left	Arterial	None
43	Capt. Max Page	Bullet	Type entry and exit. No primary hæmorrhage	Superficial fem. lower third right	Arterial	None
44	Capt. Burn	No information	Small slit in groin. No history of primary hæmorrhage	Common fem. left	Arterial	None
45	Capt. Max Page	Bullet	Type entry and exit. Free primary hæmorrhage	Common fem. left	Arterial	None
46	Lieut. Anderson	No information	No history of primary hæmorrhage. Entry wound over Hunter's canal	Middle third superficial fem.	Arterial	Sec. hæmorrhage ninth, twelfth, and thirteenth days

ANEURYSMS AND ANEURYSMAL VARICES—*continued.*

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
None	Double ligature	Cured	Wound of artery, three-quarters of an inch long, one inch above bifurcation
None	Ligature	Cured	Complete perforation of artery and perforation of vein. Shell fragment still lodged in vein. Only systolic bruit. Fair radial pulse returned fourth day
None	Complete rest	Transferred	Thrill and double murmur. Radial pulse smaller than left. Some dilatation of veins of forearm
None	Portion of artery excised with venæ comites	Cured	Small sac found in connection with artery, communication between the inner vena comes and artery
—	Double ligature and excision	Cured	
None	Double ligature of artery	Cured	Small lateral wound of artery excised, three inches of vein thrombosed. Bullet struck femur and carried small fragments of bone into track
None	Double ligature of artery	Cured	Indication for operation, cellulitis of thigh. Lateral wound of vessel. See *Fig.* 123 *B*
None	Double ligature artery tenth day. Piece of vessel excised	Cured	Indication for operation, secondary hæmorrhage. Lateral wound of vessel. See *Fig.* 123 *D*
None	Double ligature of artery *in situ*	Cured	Complete division of vessel, 'smashed up'
None	Double ligature of artery	Cured	Gaseous cellulitis of leg
None	Double ligature	Cured	Perforation of artery. Vein thrombosed
Gangrene of foot and lower third of leg	Artery and vein ligatured	Cured	Sent home with localized gangrene of foot. 'Slamming' systolic murmur
None	Artery ligatured twenty-seventh day	Cured	Much wasting of limb subsequent to operation. Otherwise did well
None	Double ligature tenth day	Died	Lateral wound of artery. Indication for operation, cellulitis of thigh and secondary hæmorrhage. Branches ligatured on thirteenth day

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VENOUS

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondary Hæmorrhage: Date
FEMORAL—*continued.*						
47	Lt.-Col. Butler	Bullet	Type entry. No exit. No history of primary hæmorrhage	Common fem.	Arterial	None
48	Capt. Wolfenden	Bullet	Type entry. Explosive exit in left buttock. No history of primary hæmorrhage	Common fem. left	Arterial	Secondary hæmorrhage fourth and fifth days.
49	Capt. Rahili	Shell	Very free primary hæmorrhage. Entry and exit large	Middle third rt. superficial fem.	Arterial	None
50	Capt. Wolfenden	No information	Entry outer margin anterior surface of thigh. Large exit in adductor region	Superficial fem. middle third left	Arterial	Secondary hæmorrhage
51	Capt. Wolfenden	Shell	Entry wound only, under surface of thigh. No history of primary hæmorrhage	Superficial fem. junction of lwr. and middle third left	Arterial	None
52	Capt. Wolfenden	Bullet	No history of primary hæmorrhage	Superficial fem. middle third left	Arterial	None
53	—	Bullet	Type entry and exit	Common fem. right	Arterial	None
54	—	Bullet	No history of primary hæmorrhage	Common fem. right	Arterial	None
55	Capt. Martin	Bullet	Type entry and exit wounds. No history of primary hæmorrhage	Common fem. right	Arterial	None
56	Major Hull	No information	Wound lower end of Hunter's canal. No history of primary hæmorrhage	Superficial fem. middle third	Arterial	None
57	Major Maynard Heath	Bullet	Type entry and exit	Superficial fem. middle third	Arterio-venous aneurysm	—
58	Lt.-Col. Gordon Watson	Bullet	Type entry wound. Bullet retained right side of scrotum. Much primary swelling of scrotum and effusion in left iliac fossa, and œdema of limb	Left common femoral	Arterio-venous aneurysm	None
59	Capt. Max Page	Bullet	No great primary hæmorrhage	Left superficial fem. middle third	Arterio-venous aneurysm	None
60	Capt. Max Page	Bullet	Type entry. Exit explosive	Left superficial fem. middle third	Arterio-venous aneurysm	None

ANEURYSMS AND ANEURYSMAL VARICES—*continued.*

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
None	Artery ligatured fourth day	Cured	Indication for operation, gaseous cellulitis of thigh. Large pulsating swelling extending up to Poupart's ligament
Threatening before death after hæm. fourth day	Artery ligatured fourth day	Died	Hæmatoma extended widely into iliac fossa. Indication for operation, suppuration in thigh. Secondary hæmorrhage from collateral branches. Lateral wound of artery
None	Artery and vein ligatured twenty-second day	Cured	Wound of artery involving three-fifths of lumen. Indication for operation, secondary extension
None	Operation third day. Artery ligatured, portion excised	Cured	Indication for operation, widespread cellulitis of thigh. Lateral wound of artery
None	Double ligature. Operation tenth day	Cured	Indication for operation, surface redness. See p. 368 *Fig.* 123 *A*
None	Double ligature. Operation twentieth day	Cured	Fractured femur Lateral wound of vessel at origin of profunda. Surrounding tissues acutely inflamed
None	Complete rest	Transferred	Systolic bruit, rather high pitched, conducted mainly downwards
None	Complete rest	Transferred	Fractured upper end of femur. No bruit present
None	Complete rest	Transferred	Very small aneurysm. See *Fig.* 136, p. 393
Gangrene to middle of leg	Amputation	Transferred	Large swelling due to coagulum, and much ecchymosis
None	Tumour laid open fourteenth day. Artery tied. Free hæmorrhage from branches controlled by pressure forceps	Cured	Seven days after operation forceps came away and wound healed
None	Complete rest	Transferred	Double murmur, systolic element of 'sledge-hammer type audible at cardiac apex. Thrill and bullet palpable in scrotum. Extreme anæmia
Patch of gangrene on sole of foot	Double ligature of artery. Distal ligature of vein	Cured	Small lateral wound of artery. Complete division of vein. Indication for operation, gangrene of foot. See text, p. 395
Gangrene of foot and lower third of leg	Common superficial and deep femoral ligatured fourth day	Died	Patient died from gaseous cellulitis of buttock, second day. Indication for operation, gangrene of foot. Large tumour. Fractured neck of femur

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VENOUS

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondary Hæmorrhage: Date
FEMORAL—*continued.*						
61	Lieut. Colquhoun	Bullet	Type entry. Exit explosive. Severe primary hæmorrhage	Left superficial femoral	Arterial	None
62	Capt. Wolfenden	Bullet	Type entry. Retained. No history of primary hæmorrhage	Left superficial fem. middle third	Arterio-venous aneurysm	None
63	Major Gillies	Bullet	Type wounds. Fairly severe primary hæmorrhage	Right common femoral	Arterio-venous aneurysm	None
64	Capt. Wolfenden	Bullet	Oblique wound just extending to line of femoral vessels. No history of primary hæmorrhage	Rt. superficial fem. lower third	Varix	None
65	Capt. Clementi Smith	No information	Wound oblique, track crossing lower quarter Hunter's canal. No history of prim. hæmorrhage	Left superficial fem. lower third	Varix	None
66	Capt. Kelly	No information	Small slit 1½ inches below Poupart's ligament. Severe primary hæmorrhage	Left common femoral	Varix	None
67	Capt. Greaves	Shrapnel ball	Wound of entry small. Retained. A good deal of primary hæmorrhage	Left common femoral	Varix	None
68	Major Gillies	Bullet	Type entry and exit. A good deal of primary hæmorrhage	Left common femoral	Varix	None
69	Capt. Oliver	Shell	Wound 1¼ by 1 in., apparently superficial	Left profunda femoris	Arterial	None
70	Capt. Max Page	No information	Slit wound above inner third Poupart. No history of primary hæmor.	Left profunda femoris	Arterial	Secondary hæmorrhage
71	Capt. Max Page	No information	Wound traversing buttocks and rectum. No history of primary hæm.	Left profunda femoris	Arterial	Secondary hæmorrhage
72	Capt. Oliver	No information	Wound over origin of profunda, about 1½-in. circle. Clot protruding. No history of primary hæmorrhage	Internal circumflex branch of profunda	Arterial	None
POPLITEAL.						
73	Capt. Martin	Shell	Free primary hæmorrhage	Left	Arterial	None
74	Capt. West	Bullet	Small entry and exit. No history of primary hæmorrhage	Left	Arterial	None

ANEURYSMS AND ANEURYSMAL VARICES—*continued.*

Gangrene	Treatment	Result	Notes. Complications
None	Artery ligatured	Cured	Fracture of femur, two inches destroyed
None	Complete rest	Transferred	Systolic element of the murmur heard at cardiac apex
None	Complete rest	Transferred	Murmur audible over every part of limb. No thrill
None	Hunter's canal opened. Communication not found	Transferred	Explored artery not ligatured. See text, p. 396
None	Operation. One inch of vessels excised seventy-third day	Cured	Gaseous cellulitis of thigh on admission
None	Complete rest	Transferred	Typical varix. No symptoms
None	Complete rest	Transferred	General thrombosis of limb with much fever. General condition good when patient went home—thrill more localized, murmur quieter
None	Complete rest	Transferred	Machinery murmur conducted upwards and along whole of leg, not heard in heart
Gangrene of toes	Common femoral ligatured	Died	Septicæmia. See text, p. 397
Gangrene of foot	External iliac ligatured on fifteenth day, and common femoral on sixteenth day	Died	Suppuration and incipient gangrene at time of operation. Recurrent secondary hæmorrhage and gangrene causes of death
None	Common femoral tied	Died	Artery completely divided at point of origin. Large hæmatoma in Scarpa's triangle. See text, p. 397
None	Hæmatoma laid open and interior circumflex artery ligatured	Cured	See text, p. 397
Threatened	Artery and vein tied 24 hours after wound for threatening gangrene	Cured	Operation at clearing station. At base patient was found to have hæmarthrosis, and bullet in knee-joint. Leg in good condition six days later
Gangrene of whole foot. Sec. thrombosis of leg	Double ligature of artery	Cured	Lateral wound inner side of artery. Azygos articular arising opposite wound. Vein severed. Fracture of femur. Hæmarthrosis. Gangrene arrested.

[*Continued on next page*

TABLE OF ARTERIAL OR ARTERIO-VENOUS

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Arterial or Arterio-Venous Aneurysm, or Aneurysmal Varix	Secondary Hæmorrhage: Date
POPLITEAL—*continued.*						
75	Capt. West	Bullet	Type wound. No history of primary hæmorrhage	Right	Arterial	None
76	—	Shell	Lacerated wound of popliteal space left side. No history of primary hæmorrhage	Left	Arterial	None
77	Capt. Rankin	Bullet	Entry wound inner and upper part of popliteal space. No primary hæmorrhage	Left	Arterio-venous	None
78	Capt. Greaves	Shell	Entry wound upper part of popliteal space inner side. No history of primary hæmorrhage	Right, upper third	Arterial	None
79	Col. Scott	No information	Not much primary hæmorrhage	Left	Arterial	None
80	Capt. Oliver	Bullet	Type wound	—	Arterial	None
81	Major Littler Jones	Bullet	Type wounds. No primary hæmorrhage	Right	Arterio-venous	None
82	Col. Elder	Bullet	Entry, type. Bullet retained. No primary hæmorrhage	Left	Arterial	None
TIBIAL.						
83	Lt.-Col. Butler	Shell	Wound size of shilling 3 in. above interior malleolus, communicating with fracture. No history of primary hæmorrhage	Left posterior tibial lower third	Arterial	Severe about fifteenth day
84	Capt. Clementi Smith	Bullet	Type entry and exit. No history of primary hæmorrhage	Left posterior tibial	Arterial	Slight first three days
85	Capt. Kelly	Bullet	Large explosive exit in calf	Right anterior tibial	Arterial	None

ANEURYSMS AND ANEURYSMAL VARICES—*continued.*

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
Gangrene of foot	Leg amputated	Recovered	Three-fifths lateral wound of artery, pure perforation of vein. No aneurysm had formed, but there was a large mass of hard coagulum, especially prominent on inner aspect of thigh. See *Fig.* 126
Gangrene of foot and leg to four inches below knee	Leg amputated	Recovered	Large sac with blood-clot. Vein severed. Artery nicked
None	Complete rest	Transferred	Double murmur, systolic element 'pistol-shot' in character and conducted centrally only, just above pulsating area. Six days later conduction upwards more extensive but not 'pistol-shot' in character. Other leg had been amputated
None	Complete rest	Transferred	Murmur gradually became of lower pitch and softer. Looked like possible spontaneous cure. Artery ligatured the day after patient arrived at hospital in England. See *Figs.* 138, 139
Impending gangrene on fourth day	Artery ligated by internal incision. Amputation later lower third thigh on 17th day, for gangrene of leg	Recovered	Indication for operation, impending gangrene
Early gangrene at end of two days	Amputation of leg	Recovered	—
Early gangrene on tenth day	Artery and vein tied	Cured	Indication for operation, gangrene, which was arrested, only small patch on heel and end of great toe persisting. Effusion into knee-joint. Double murmur, systolic element conducted in both directions
None	Popliteal ligatured on 12th day	Cured	Marked œdema of leg after operation, suggesting thrombosis. Foot-drop, and loss of sensation which was returning
None	Leg amputated	Recovered	See *Fig.* 124, *a* and *b*
None	Wounds enlarged and clot cleared out. Small aneurysmal sac came away.	Cured	After operation hæmorrhage controlled by packing See *Fig.* 124, *c*
None	Double ligature of artery	Cured	Left leg amputated

INJURIES TO VESSELS WITHOUT

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Artery and Vein or Artery only	Second. Hæmorrhage. Presence or Absence of Hæmatoma
THROMBOSIS AND SUBSEQUENT EMBOLISM.						
86	Capt. Wolfenden	Bullet	Wound of neck. Retained over spine of sixth and seventh dorsal vertebræ. No history of primary hæmorrhage	Lower third right carotid	Contusion of artery	No second. hæmorrhage. No hæmatoma
87	Lt.-Col. Gordon Holmes	Bullet	Small, slight, near anterior border of sternomastoid, 1 in. below angle of jaw. No history of primary hæmorrhage	Left carotid	Contusion of artery	No second. hæm. Small circular area of induration over artery. No definite hæmatoma
88	Lt.-Col. Cameron	No information	Large wound inner side of thigh. Femoral vessels felt at bottom of wound. Very septic. No history of primary hæmorrhage	Superficial femoral	Contusion of artery	Secondary hæmorrhage eighth day. No hæmatoma
89	Capt. Bradford	? Bullet	Exit and entry, type. No past history of primary hæmorrhage	Right carotid	Contusion or complete division	No second. hæmorrhage. No hæmatoma
THROMBOSIS.						
90	Capt. Wolfenden	No information	No history of primary hæmorrhage	Left femoral	Artery thrombosed	No second. hæmorrhage
91	Capt. Mumford	Bullet	Entry small, clean, 2 in. above patella, middle of thigh. Exit ragged, dirty, just below flexure of hamstrings. No history of primary hæmorrhage	Left popliteal	Wound of vein only. Arterial thrombosis	No second. hæmorrhage. No hæmatoma
92	—	No information	Wound of thigh	Femoral	Artery injured and thrombosed	No second. hæmorrhage. No hæmatoma
93	Lieut. Harmens	No information	Wound of thigh. Large septic. Artery exposed. No history of primary hæmorrhage	Femoral	Artery thrombosed	No second. hæmorrhage. No hæmatoma
94	Lieut. Llewellyn	Bomb fragment	Entry, incised, inner side of right arm. Exit, incised, outer side of arm 1 inch below insertion of deltoid. No history of primary hæmorrhage	Brachial	Artery thrombosed, lateral thrombus	No secondary hæmorrhage

THE FORMATION OF ANEURYSM.

Distal Pulse	Gangrene	Ligature of Vessel. Amputation	Result	Notes. Complications
Normal	—	None	Transferred	Left brachial monoplegia. Paraplegia. See text, p. 358
? Left temporal pulse stronger	—	—	Transferred	Mental condition very dull, improved later. Slight hemiplegia. Pupils equal. Speech not bad, difficulty in reading. Could not write at first. See text, p. 358
No distal pulse	Gangrene chiefly of dorsum of foot, reaching to junct. middle and lower third of leg	Femoral ligatured in wound	Died	Embolism of popliteal artery
No temporal or carotid pulsation	—	—	Died	Patient unable to speak, conscious. Sweating more left side of face than right. Pupils, right larger than left, both react. Died. No P.M.
No distal pulse	No gangrene	Double ligature	Cured	—
No anterior or posterior tibial pulse	Lower leg and foot blue, cold, and insensitive	Amputation	Recovered	Suppurating knee-joint. See *Fig.* 121, and text, p. 355
No record	None	Expectant	Transferred	Leg kept in good condition. Had pulmonary embolism
No distal pulse	Gangrene of foot and leg almost to knee	Leg amputated. No ligature necessary for femoral artery	Recovered	—
Radial pulse barely perceptible	None	Vessel ligatured above and below, bruised portion excised	Cured	See *Fig.* 122, p. 356, and text, p. 357

COMPLETE DIVISION AND

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Artery and Vein or Artery only	Second. Hæmorrhage. Presence or Absence of Hæmatoma
95	—	Shell	Wound of popliteal space	Popliteal	Artery and vein	No second. hæmorrhage. No hæmatoma
96	Major Hull	Bullet	Transverse wound of ham. Primary hæmorrhage	Left popliteal	Artery completely divided. Vein thrombosed	No second. hæmorrhage. No hæmatoma
97	Capt. Mumford	Bullet	Entry above patella, left side. Exit, flexure of ham. No history of primary hæmorrhage	Left popliteal	Artery divided at the junction of upper and middle thirds. Vein unhurt	No second. hæmorrhage. No hæmatoma
98	Capt. Oliver	Bullet	Type entry and exit. No history of primary hæmorrhage	Left axillary	Artery completely divided? or contused	No second. hæmorrhage. Probable hæmatoma
99	Lt.-Col. Gordon Holmes	Bullet	Entry anterior axillary fold, exit posterior axillary fold. No history of primary hæmorrhage	Axillary	Artery completely divided? or contused	No second. hæmorrhage. No hæmatoma
100	Capt. Kelly	Bullet	Entry one inch below and two-thirds inch inside coracoid process. Exit post. axillary fold. Severe primary hæmorrhage	Axillary	Artery completely divided? or contused	No second. hæmorrhage. No hæmatoma
101	Lt.-Col. Moore	Bullet	Wound track crossing junction of second and third parts axillary artery. No history of primary hæmor.	Axillary junction of second and third part	Artery completely divided? or contused	No second. hæmorrhage. No hæmatoma
102	Capt. West	Bullet	Entry just below right coracoid process. Exit outer margin of erector spinæ	Axillary	Artery completely divided? or contused	No second. hæmorrhage. No hæmatoma
103	Lt.-Col. Gordon Watson	Bullet	Bullet retained supraclavicular fossa. No history of primary hæmorrhage	Brachial	Artery completely divided	No second. hæmorrhage
104	Lt.-Col. Gordon-Watson	Bullet	No primary hæmorrhage	Third part subclavian right	Artery completely divided	No second. hæmorrhage. No hæmatoma
105	Col. Cameron	No information	Wound of popliteal space. No history of primary hæmorrhage	Popliteal artery	Complete division	Secondary hæmorrhage eighth day
106	Major Sinclair	Rifle Grenade	Entry just to outer side of anterior axillary fold. Exit half way down axillary border of scapula	Right brachial	Complete division? or contusion	No second. hæmorrhage. No hæmatoma
107	Capt. Oliver	Time fuse	Entry just above centre of outer aspect of arm, 2 in. by 1 in. Retained. No history of primary hæmor.	Right brachial	Large tear in wall of brachial artery	No second. hæmorrhage. No hæmatoma

WOUNDS OF ARTERIES.

Distal Pulse	Gangrene	Ligature of Vessel. Amputation	Result	Notes. Complications
None	Gangrene of leg	Amputation	Recovered	—
No anterior or posterior tibial pulse	Impending gangrene of foot and leg	Both ends of artery ligatrd. for impending gangrene. Second amputation twelfth day	Recovered	Ends of artery one inch apart. Clot in proximal end. Vein unwounded but thrombosed
No pulsation in tibial arteries	Gangrene of foot and leg	Both ends of artery lig. Amp. fifteenth day	Recovered	Bad attack of septic bronchopneumonia
No brachial or radial pulse	No gangrene	—	Transferred	Monoplegia all muscles, some sensation in radial and circumflex areas. No murmur
No radial, brachial, or axillary pulse	No gangrene	—	Transferred	Brachial monoplegia
No pulsation in radial or brachial	No gangrene	—	Transferred	Brachial monoplegia. Hæmothorax
No radial pulse	No gangrene	—	Transferred	Brachial monoplegia. Hæmothorax. No murmur. No pulsation below site of wound
No radial or brachial pulse	No gangrene	—	Transferred	Palsy of branches of posterior cord. No murmur
No radial pulse	All digits dry gangrene to metacarpo-phal. joint	Brachial artery ligatured	Transferred	Musculospiral injured by fracture of humerus. Piece of bone in sheath of nerve
Radial pulse absent	No gangrene		Recovered	Spontaneous cessation of hæmorrhage. Division of middle and posterior cords of brachial plexus. See text, p. 385
No record	Gangrene of foot and leg to middle third	Thigh amputated	Recovered	Amputation for secondary hæmorrhage and gangrene which was secondary to hæmorrhage
Radial pulse minimal	No gangrene	—	Transferred	Complete loss of power in arm, and lowered sensation. Two ribs fractured. No murmur
No radial pulse before or after operation	No gangrene	Proximal ligature	Cured	Missile removed. Large tear in wall of brachial artery

UNCLASSIFIED

No.	Under Care of	Bullet or Shell	Nature of Wound. Primary Hæmorrhage	Position in Course of Artery	Vascular Lesion	Secondary Hæmorrhage: Date
POPLITEAL ARTERY AND VEIN.						
108	Major Stoney Archer	Bullet	No history of primary hæmorrhage. Bullet palpable in popliteal space	Popliteal	Puncture of artery, transfixion of vein	Free hæm. on removal of bullet
FEMORAL VEIN.						
109	Capt. Oliver	Shrapnel ball	Ball retained left buttock. Free primary hæmorrhage	Vein in Hunter's canal	Venous injury	Sec. hæm. controlled by finger
PRIMARY LIGATURE (BRACHIAL).						
110	Capt. Clutterbuck	No information	Free primary hæmorrhage. Puttee tourniquet for 16 hours	Left brachial	—	None
111	—	No information	Severe primary hæmorrhage	Brachial	—	Sec. hæm. after four pints saline in axilla

VASCULAR LESIONS.

GANGRENE	TREATMENT	RESULT	NOTES. COMPLICATIONS
None	Vessels ligatured	Cured	See *Fig.* 140
None	Femoral vein tied at top of Hunter's canal, with second ligature above	Cured	Discharged with normal limb
Gangrene of finger tips. Terminal phalanx mummified	Artery tied at casualty clearing station. Amputation of arm for prolonged sepsis	Recovered	—
Gangrene of forearm and hand	Vessel tied in wound. Amputation later	Recovered	—

ON GUNSHOT WOUNDS OF THE SHOULDER.

By Major Sir JOHN BLAND-SUTTON, LL.D., R.A.M C.(T.)

Experience in dealing with wounds inflicted by the *Spitzgeschosse* teaches surgeons that this missile finds its way into more extraordinary situations by chance than it could be placed in by design. It is also true that soldiers belonging to what is called by official drollery the Expeditionary Force, sustain some very remarkable injuries from this bullet, and its splintering effects on long bones are often very great and out of proportion to its size.

In this communication attention will be confined to bullet wounds of the shoulder. The high velocity of bullets projected from modern rifles led surgeons, from experience gained in the South African War, to believe that they would traverse the shaft of a bone and leave in many instances a sharply-cut tunnel. Surgeons have told me of instances in which a Mauser bullet traversed a metacarpal bone and caused little inconvenience to the soldier. The damage to bone resulting from the impact of an *S.* bullet has upset all preconceived ideas. My attention has been directed to wounds of the upper end of the humerus caused by this bullet, not only from the special nature of the injury, but also in regard to its treatment.

During the last twenty years I have treated comminuted fractures of the head of the humerus by removal of the fragments. I never saw a *compound* comminuted fracture of the head of the humerus until the present war supplied me freely with examples. All the soldiers with this injury, coming under my care, I have treated by opening up the wound and removing the fragments of bone. It is important to preserve the long tendon of the biceps, and it is often spared by the bullet. The cavity left by the removal of the pieces of bone is drained freely—a matter of more importance than the antiseptic re-agent employed—with the object of freeing the wound from pathogenic micro-organisms. The results of this method of treatment have been uniformly good: it shortens convalescence, and saves the wounded soldier much suffering. I make these observations with confidence, because I have seen men with these injuries who have been treated by what are called milder measures, which consist in leaving the septic and necrotic pieces of bones in the wound, with the hope that they will amalgamate. The disadvantages of allowing dead pieces of bone to remain in such wounds are well known; they give endless trouble, keep sinuses open for months, or years, and repeated operations are required for their removal.

The way an *S.* bullet breaks up a bone is illustrated in *Fig.* 141. An officer had his shoulder perforated by a rifle bullet in the fighting around Hill 60. On admission to the 3rd London General Hospital, he had a septic wound discharging pus from two openings. A radiogram showed that the head of the humerus had been reduced to small fragments. I opened up the wound and extracted seventeen pieces of bone. Some pieces had been driven

through the wound of exit on the back of the shoulder. In the course of the operation the glenoid cavity was found broken, and three fragments of this part of the scapula were removed. The operation was followed by quick recovery and a useful limb. I preserved the fragments removed at the operation, and subsequently the museum attendant carefully fitted them together, like a jig-saw puzzle, and from the partially restored bone the drawings were made. Many pieces were too small to be fitted in, and some had been driven from the limb by the impact of the bullet.

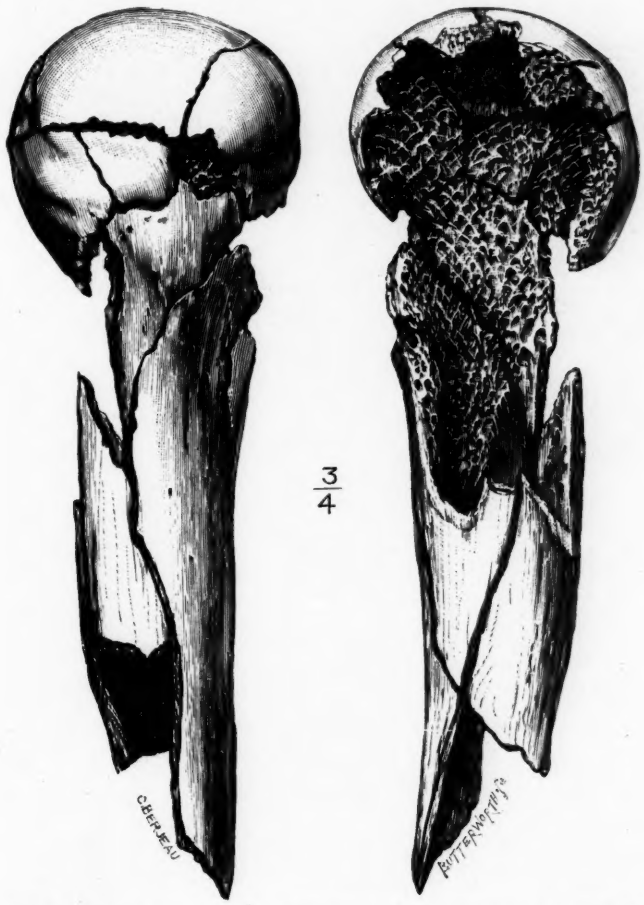


FIG. 141.—TWO VIEWS OF THE UPPER END OF A HUMERUS BROKEN INTO FRAGMENTS BY AN *S.* BULLET. After removal the pieces of bone were cemented together.

An extreme example occurred in an officer wounded at short range near Ypres. A fragmented bullet hit him in the shoulder, reduced the upper part of the humerus to fragments, and split the remainder of the humeral shaft vertically to the elbow-joint. When he came under my care, pieces of bone were sticking out of the wound of exit; he was very ill, septic, and exhibited signs so suggestive of tetanus that antitetanic serum was administered. In spite of these unfavourable symptoms I refused to amputate the limb. I

opened up the wounds, removed thirty pieces of bone, swabbed the cavity with tincture of iodine, and drained it freely. Quick recovery followed. This officer married three months later, and returned to duty as a staff-officer. In the course of the operation, I found some portions of the ferro-nickel sheath of the bullet among the fragments of bone. This confirmed the officer's opinion that the injury was caused by a bullet.

FIG. 142.—HEAD OF THE HUMERUS. From an Australian, age 19, wounded during the landing on the Gallipoli Peninsula. The epiphyseal line is clearly visible.

An injury with somewhat different features came under my care in an Australian wounded during the landing on the Gallipoli Peninsula. A bullet detached a piece of skin and deltoid muscle, and made a deep furrow in the head of the humerus (*Fig.* 142). When this soldier came under my care, the shoulder-joint was suppurating freely, the bone was exposed, and so soft that it could be penetrated easily by the points of forceps. I excised the head of the bone, the operation being followed by a quick and uneventful recovery. Two months later the soldier could use the limb freely and without discomfort.

FIG. 143.—HEAD OF THE HUMERUS, AND FRAGMENTS OF ITS SURGICAL NECK. Excised from a soldier, age 22, wounded by a bullet in the fighting at Loos. The epiphyseal line is clearly visible.

In the early months of the war I reserved this mode of treating injuries of the humerus for cases where the damage was confined to the head of the bone. In cases where the comminution affected that portion of the humerus known as the surgical neck, I removed the fragments, and left the head of the bone, hoping that when the septic infection subsided, the breach might be repaired by plating or grafting. This in practice proved unsound. In one case secondary hæmorrhage led to amputation. In another, an exam-

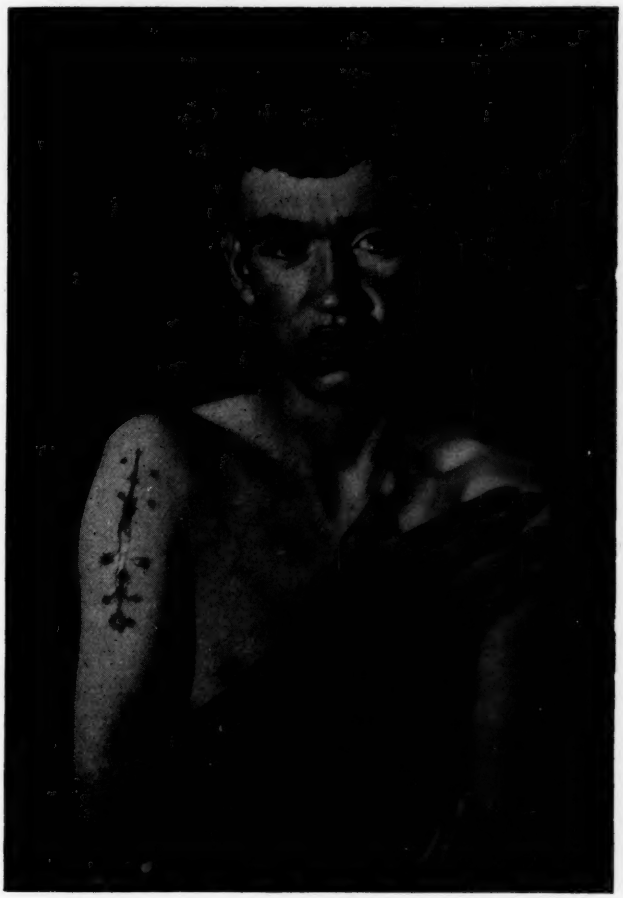


FIG. 144.—A SOLDIER AFTER EXCISION OF THE UPPER END OF THE HUMERUS FOR A COMPOUND COMMINUTED GUNSHOT WOUND. He can place the hand on the opposite shoulder.

ination of the head of the bone, ten weeks after injury, showed it to be so softened by bacterial action that it had to be removed in order to allow the wound to heal. These, and similar cases, induced me to extirpate the head of the humerus when the shaft of the bone immediately below the head had been extensively comminuted.

A soldier, age 22, was hit in the shoulder by a bullet in the attack on Loos. He came under my care in the Middlesex Hospital five days later.

The bullet entered the bone at the surgical neck, comminuting it, passed under the scapula, and emerged by a wide opening in the skin near the middle of the patient's back. On admission, the shoulder was swollen, tender, and glossy; offensive oily pus oozed from a small circular aperture of entrance near the middle of the deltoid. Three days later I opened the wound freely, removed the loose fragments of bone, and excised the head of the humerus. The glenoid fossa was intact, and the long tendon of the biceps uninjured. The cavity left by the removal of the bone was drained. The fever and pain quickly subsided, the wound soon granulated, and within a month the lad left for a convalescent home with his wound soundly healed.

The utility of the limb after this operation depends in a large measure on the extent of the damage to the deltoid muscle and the circumflex nerve. When the bullet merely perforates the muscle, and the damage to the humerus is limited to the part above the insertion of the deltoid, the limb can be freely used. In the patient the head of whose humerus is represented in *Fig.* 143, a portion of the deltoid attachment remained on the shaft of the humerus, and this lad, as the photograph (*Fig.* 144) shows, can place his hand on the opposite shoulder. He was able to do this easily a month after the operation. When the deltoid is extensively damaged, the limb hangs from the scapula like a flail; nevertheless, it is more useful than the most ingenious arm made by the cleverest maker of artificial limbs.

The best results are attained when the operation is performed before the detached pieces of bone become united by dense fibrous tissue, or embedded in callus. Early removal of the fragments simplifies the operation, quickens the recovery, relieves pain, and ensures a useful limb. It is true that removal of the infected fragments is followed by a sharp rise of temperature; this persists for a few days, but quickly subsides if free drainage has been provided. Surgical timidity in dealing with such conditions is unfortunate for the wounded soldier. Free drainage is essential for success, and the particular kind of antiseptic agent employed matters little. This method of treating gunshot injuries of the shoulder is applicable to similar injuries of the elbow.

The damaged head of the humerus is often left by surgeons, under the impression that when the sepsis subsides some form of plating may be employed. Nothing can be more disappointing; for at the end of many months, when the surgeon attempts an operation, he finds that the bacteria have so softened the bone that an awl passes through it as easily as a taster enters cheese. With such softened bone wire and screws have no place.

ON THE TREATMENT OF WOUNDS IN WAR.

By Sir W. WATSON CHEYNE, Bart., C.B., F.R.S., P.R.C.S.

Since the war began I have published no less than five communications* on the subject of the treatment of wounds in war, and therefore feel that I ought to apologize to my professional brethren for continuing to worry them on this matter. I resolved, indeed, some time ago to let the matter rest for a while, as regards further publication, in the hope that some other surgeon would take it up. I have, however, been earnestly requested from several quarters to deal with this question once more, especially with reference to the recent papers by Sir Almroth Wright in the *Lancet* of Oct. 30, Nov. 6, and Nov. 13, and that is my excuse for the following communication.

I need hardly remind my readers that there are two different lines of treatment advocated at the present time with the view of getting rid of the infection which takes place at and soon after the infliction of these injuries; the one is to attempt to destroy the bacteria which have gained access to the wound as soon as possible by chemical means, i.e., by the use of antiseptics; the other, to leave the destruction of these bacteria to the natural protective processes of the body, efforts of various kinds being made to aid or increase the action of the latter. Of these, the first is at present very unpopular; it is old-fashioned, and savours too much of Teutonic methods. The second is much more popular; it is quite the latest thing in wound treatment; it has a very scientific flavour about it; and it is a less brutal and more gentlemanly plan.

The history of the treatment of these wounds is a most interesting subject, and in the course of centuries every conceivable view as to the causes of the troubles which follow them has been put forward, and every variety of wound treatment has been employed, from incantations down to cleanliness and the use of antiseptics. But in spite of all efforts, very little impression was made on the incidence or severity of the infective diseases of wounds until the latter part of last century. It is true that with methods introduced during the first half of the century, such as the open method, irrigation, the water bath, free drainage, increased cleanliness, the application of various antiseptic substances, and so on, some improvement followed; but still the conditions were very bad, and such a thing as an aseptic wound, especially when inflicted accidentally, was practically unknown. And then Lister began to work on a new plan, and *suddenly* the entire aspect of affairs was changed, and the whole practice of surgery was revolutionized.

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* (1) "Address on the Treatment of Wounds in War," *Lancet*, Nov. 21, 1914; (2) Hunterian Oration, *Lancet*, Feb. 27, 1915; (3) *Journal of the Royal Naval Medical Service*, No. 1, April, 1915; (4) "Sir Almroth Wright's Lecture on the Treatment of Wounds in War," *Lancet*, May 9, 1915; (5) "Observations on the Treatment of Wounds in War," *Lancet*, July 31, 1915.

LISTER'S PROCEDURE.

It seems to me that at the present time there are no more important questions for the surgeon at the front to ask himself than these :—

1. *What was it that Lister did in the treatment of infected wounds which led to the great revolution in surgery which followed his work?*

2. *Why is it that I am not getting results similar to those which were obtained by Lister as long ago as* 1866 ?

For it must be realized that the military surgery of the present day, as regards results, has not advanced as one would have expected.

What, then, was it that Lister did which changed the whole aspect of affairs ? Here is what he did in the case of a boy whose leg was crushed by the wheels of an omnibus.*

> " When I saw the child," Lister writes, " after an unavoidable delay of three hours, he was greatly prostrated by shock as well as hæmorrhage, so much so that amputation appeared likely to afford but a slender chance of life, although the state of the injured parts seemed to admit of no alternative. The tibia, which was broken about its middle, lay exposed in a wound occupying almost the entire length and breadth of the inner aspect of the leg, reaching from the inner condyle of the femur to within an inch and a quarter of the tip of the internal malleolus ; the skin having been stripped back so as to lay bare the gastrocnemius as well as the bone. The large flap of integument was perforated about two inches from its edge opposite to the seat of fracture, and there was also an opening in the skin on the outer side of the leg, implying that the violence had acted with full force upon the whole thickness of the limb. Yet the bone was not comminuted, and the muscles, though severely contused, were not much lacerated, while the anterior tibial artery was felt beating in the foot ; and, hopeless as would have been the idea of trying to save the limb by ordinary treatment, I determined to make the attempt by the help of carbolic acid."

Now observe what he did in this case, the fifth treated on his new principle, for it is most important in view of the exaggerated ideas promulgated by a number of surgeons at the present time as to the harm which may be caused by strong antiseptics. Observe, also, that the preparation of carbolic acid which he was using was very impure, and much more irritating than the purer material which is employed now.

> " Chloroform having been administered, the acid of full strength was applied with great freedom, *the contused mass being repeatedly squeezed to induce the liquid to insinuate itself into all its interstices*,† including that between the riding fragments of the tibia. The flap of skin was then brought towards its natural position, and lint soaked in the acid was placed upon the wide raw surface which still remained exposed, and over the lint a piece of sheet tin. The other openings in the integument were similarly treated, and the riding of the fragments having been corrected by extension, the limb was laid on its outer side, with the knee bent, upon

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* " On a New Method of Treating Compound Fracture, Abscess, etc." (*Case* 5), *Lancet*, 1867, i.

† The italics are mine.

> a pasteboard splint moulded to the leg and foot and strengthened by a temporary wooden splint. A porous cloth was applied over the tin to absorb the blood and serum which must escape from beneath its edges, and the whole apparatus was secured with a roller bandage."

As regards the further progress of this case, the wound filled up with blood-clot, which became firm and adherent to the walls of the wound. This clot remained there day after day, becoming organized in its deeper part, and no suppuration occurred. The tin plate was removed every day, and fresh carbolic acid was painted on the surface of the clot so as to keep up the antiseptic action. After about a fortnight the detached edges of this crust of clot and carbolic acid were clipped away, and a lotion of sulphite of potash was applied over the exposed rim of the crust, to permit cicatrization, which the carbolic acid tended to check.

Already in his third case Lister had observed organization of blood-clot, which was quite a new phenomenon to him. Speaking of this, he says :—

> " Thus, the blood which has been acted on by carbolic acid, though greatly altered in physical characters, and doubtless chemically also, had not been rendered unsuitable for serving as pabulum for the growing elements of new tissue in its vicinity."

And, further, in speaking of healing in connection with this mass of clot, he says :—

> " At length, nearly four weeks after the accident, I tore it (the clot) off from the vascular surface beneath, which bled as I did so. The crust had preserved the subjacent parts from disturbance as effectually as if it had been a piece of living integument ; and it is worthy of remark that the vascular surface below had not the pulpy softness of granulations, but was comparatively firm and substantial. The bit of crust still smelt of carbolic acid, though none had been applied for five days."

In the fifth case, described above, he not only observed this organization of the blood-clot, but also absorption and disappearance of a piece of dead bone, a phenomenon only met with in aseptic wounds.

In the case which I have narrated a very interesting and instructive complication arose. On the fractured leg there was at one side a small wound which was not treated by carbolic acid. After some days it was observed that this sore, instead of healing, was increasing in size, and presently hospital gangrene developed in it and caused a good deal of trouble. Thus we have the very remarkable fact that not only in the same patient, but in the same limb, we have a large and very grave wound following an absolutely aseptic course, while in the vicinity a trivial wound became the seat of hospital gangrene. If, as Sir Almroth Wright suggests, the main value of antiseptics is due to their production of a flow of serum, why did that serum prevent hospital gangrene in the large wound and not in the small one. The difference between the two really lay in the presence or absence of the strong carbolic acid.

Among Lister's early cases of compound fracture, two developed abscesses, and in so far were failures ; but there was no spreading infective disease, as was previously the case, and as the other cases had been successful,

there was sufficient evidence to show that the failure in these two cases was due to some imperfection in the details of the procedure, and not to a faulty principle.

At the time this paper was written he had already progressed from the use of impure carbolic acid to carbolic oil and carbolic putty, and he refers to the treatment of psoas and other tuberculous abscesses with these preparations. To his delight he found that, when so treated, instead of suppurating freely after they were opened, as was formerly the case, and as I am sorry to say is frequently the case at the present time under the so-called aseptic treatment, suppuration did not occur, and the sinuses healed in course of time. He says :

> "I have opened numerous abscesses connected with caries of the vertebræ, the hip, ankle, and elbow, and in all cases *I have found the discharges become in a few days trifling in amount, and in many it has ceased to be puriform after the first twenty-four hours.*"

He says, with regard to this new method of treating abscesses :—

> "It is based, like the treatment of compound fracture, on the antiseptic principle, and the material employed is essentially the same—viz., carbolic acid—but differently applied in accordance with the difference of the circumstances. In compound fracture there is an irregular wound which has probably been exposed to the air for hours before it is seen by the surgeon, and may therefore contain in its interstices the atmospheric germs which are the causes of decomposition, and these must be destroyed by the energetic application of the antiseptic agent. In an unopened abscess" (he is here referring to tuberculous abscesses), "on the other hand, as a general rule no septic organisms are present, so that it is not necessary to introduce the carbolic acid into the interior. Here the essential object is to guard against the introduction of living particles from without, at the same time that a free exit is afforded for the constant discharge of the contents."

Thus in this paper he already formulates the guiding principles of treatment in the two great classes of wounds—viz., (1) Those inflicted accidentally, in which, therefore, infection—which at that time he attributed chiefly to 'atmospheric germs'—had already occurred before the patient came under the care of the surgeon ; and (2) Those made by the surgeon through previously unbroken skin.

It does not concern us here to follow up the subsequent development of Lister's methods ; the point is that he began his work with compound fractures, and that he did something to these fractures which produced very remarkable improvement in the results, an improvement so self-evident that no one could be in any doubt about it (very different in this respect from the results of brine and vaccine therapy), and one which completely revolutionized surgical work.

Now what Lister tried to accomplish was to kill the bacteria which had entered these wounds before they had had time to develop and take root in the body ; and the substance which he chose for his first experiments was a fluid, chemically impure, but which contained a large proportion of carbolic acid and cresol. This he applied to the wound undiluted, and he used it in no niggardly manner, for not only was the impure acid applied all

over the wound, but " the contused mass was repeatedly squeezed to induce the liquid to insinuate itself into all its interstices." He did not find that this acid caused sloughing of the surface of the wound, or led to extension of the septic processes, or that the blood-clot which formed plugged the wound and permitted the development of the bacteria in the tissues; in fact, he found none of the horrible things which we are told by our colleagues in France happen to infected wounds when strong antiseptics are applied. Had this been the case, had Lister found that his applications made matters worse instead of better, he would have dropped the experiments at once, and the revolution in surgery would not have taken place. Is it conceivable that, if antiseptics were so injurious and inefficient, that most remarkable pilgrimage of surgeons from all the ends of the earth to Glasgow and Edinburgh would have occurred and gone on for years? And Lister showed to those visitors all his cases, and among them there were always cases of accidental wounds and compound fractures which were following an aseptic course.

It is very remarkable that in the face of these facts some bacteriologists calmly dismiss the subject of disinfection of wounds, and state that antiseptics are absolutely useless for this purpose; the truth is, it is not that antiseptics are useless, but that they are not employed in such a manner that useful results could be expected. Sir Almroth Wright suggests " that favourable results *occasionally* (?) manifesting themselves after antiseptic treatment might well be interpreted in the sense here suggested " : i.e., as lymphagogues, mechanically clearing out the discharge, causing temporary hyperæmia, keeping the wound moist, and so on. Such a statement, which is wrong in its premises, does not need any refutation by me.

This being the answer to the question as to what it was that Lister did that revolutionized surgery, one would have thought that on the outbreak of war, the first impulse would have been to try to reproduce Lister's results. Unfortunately, of late years a most unaccountable prejudice has arisen against antiseptics, with the result that students have not been educated in their use: indeed they have been taught to decry their value, and to look on them as old-fashioned and very objectionable substances. Hence, when the war began, they and also their teachers were unprepared; and when it became evident that their usual methods, sterilized dressings, salt solution, etc., were quite inefficient, and that it might be worth while to turn to antiseptics, they had no clear ideas as to what to do, and consequently their efforts were unsuccessful. And the bacteriologists, not having any practical experience, have accepted such results as definite, and it does not seem to have occurred to them that perhaps those who had had more experience of antiseptics might have done better.

GENERAL REMARKS ON DISINFECTION AND ANTISEPTICS.

By disinfection of a wound, we mean the complete destruction of the bacteria which have entered it, so that it is transformed into the condition of a wound which the surgeon has made aseptically through unbroken skin. It should then heal without local or general disturbance, even though it cannot be closed, just as in the case of large aseptic operations where the skin edges cannot be brought together. That this result was obtained by Lister I have

just shown; it has also been the ordinary result in cases of compound fractures in civilian practice in the hands of his pupils.

Now, we may meet with these infected wounds under two conditions: (1) At or soon after their infliction, and before granulation or suppuration has occurred; and (2) At a later date, after the establishment of granulation and suppuration. The conditions in the two cases as regards the question of disinfection are very different. During the first stage, which lasts for two or three days, the bacteria, at first free in the wound, penetrate into the tissues, and are having their first battle with the tissues and the protective arrangements of the body; unless they are very few in number, or not particularly virulent, the body is usually defeated, and fails to eject the bacteria. The body, however, makes strong efforts to localize them in the part, and to surround them with a wall of highly protective tissue. If it also fails in this attempt, general infection follows, and the outlook for the patient is very bad. If, on the other hand, it succeeds, a granulating and suppurating wound is established, the battle becomes a more chronic one, and under favourable conditions generally ends in ultimate victory for the body.

Now, during the early stage the bacteria are fairly accessible to the action of destructive agents introduced into the wound; they are not deeply embedded in the tissues nor surrounded by dense masses of cells. At this stage the use of strong antiseptics will not seriously interfere with the protective arrangements* of the body, even if they do not kill all the bacteria; if they do kill all the bacteria, any damage they may have caused to the tissues while so doing is quite negligible.

In the later stage, however, the organisms are lying in the granulation tissue, more or less protected from the destructive action of antiseptics by the dense mass of granulation cells, and the chance of killing the bacteria by antiseptics at this stage is very much less than in the former case. Further, antiseptics used at that period may seriously interfere with the protective granulation wall, produce a weak spot, and thus open up a way to a general infection, or at least to a considerable local extension of the disease. Hence, while I have no hesitation in applying strong antiseptics to the wound in the first stage, and leaving them there, I am very chary indeed as to the use of antiseptics in suppurating wounds; indeed, I only use the mildest and least irritating ones, more with the view of washing away the pus than with any idea of disinfecting the wound; in fact, I never try to disinfect such wounds. It is possible that this latter view may be modified, if the anticipations of Carrel and Dakin regarding hypochlorites are fulfilled. They speak of having succeeded in disinfecting suppurating wounds after a few days' irrigation with Dakin's hypochlorite solution; if this turns out to be so in any considerable proportion of cases, I may have to modify the above remarks in the next paper I write.

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* I may point out here that I differ seriously from Sir A. Wright as to these protective arrangements. Apparently, according to him, they reside in the serum and lymph, and to him these seem the most important materials. In my opinion the protective substances in serum, and their action on bacteria, constitute only one part of the defence, and there are local protective arrangements which are possibly even of greater importance. The matter is too long to argue here, but I have referred to it in various publications, especially in the Wightman Lecture, published in the *British Journal of Children's Diseases*, August, 1908.

As a matter of practical experience, the earlier the wound is disinfected the better, and after from eight to twelve hours the chances of success are comparatively slight—unless, indeed, some attempt has been made to delay the growth of the bacteria in the interval. It has, however, been successful in some cases up to twenty-four hours. I have referred above to the hypochlorite solution, and it is quite possible that with this solution the period may be extended. With borsal, also, I think that in some cases disinfection may be accomplished at a later period than twenty-four hours —so long, indeed, as the wound has not completely granulated.

Another question which arises is whether we ought to aim at the sudden or the gradual death of the bacteria. This is an important point, as on it will depend to a considerable extent the choice of the antiseptic, its concentration, and the method of using it. Until the commencement of this war I had always aimed at the sudden death of the bacteria; but since then I have reviewed the whole subject very carefully, and, having had the opportunity of performing many experiments, I have come to the conclusion that it is not necessary to strive for the instantaneous death of the bacteria, though the sooner they die out the better. The experiments carried out by the Naval Medical Committee on the diffusibility and activity of antiseptics, which I have continued and extended during the summer and autumn, have thrown great light on the relation of bacteria to antiseptics, not only in laboratory cultivations, but also in dead and living animal tissues. We have learned that various antiseptics diffuse widely, not merely in the ordinary laboratory culture media (nutrient agar and gelatin), but also in blood-clot, and dead and living tissues, and in doing so they inhibit the growth of any bacteria which they may meet with in the course of their diffusion. And not only do they inhibit the growth of the organisms, but they also kill them in course of time. The extent of the diffusion, the inhibition of the bacterial growth, the actual destruction of the organisms, and the time taken in the latter case, vary with the medium in which the antiseptic acts, with the antiseptic substance employed, with its dose and concentration, with the length of time it acts, and with the species of bacterium exposed to its action.

The medium in which the antiseptic acts is naturally of great importance. Almost all antiseptics have their bactericidal properties, and incidentally their irritating character, much reduced in the presence of albuminous materials. Mercurial salts and iodine are good examples of this, these antiseptics combining strongly with the albumin, and losing their antiseptic properties in a very marked degree. Carbolic acid also is acted on, but not to so great an extent; salicylic acid does not seem to be so much affected; and the hypochlorites form a chloramine with the albumin which is itself antiseptic. Sir A. Wright makes great play with the inefficiency of antiseptics in pus; but his experiments have no bearing on the question of early disinfection, for we are dealing with wounds before suppuration has occurred.

Another point, which I confess had not occurred to me until I came across it in the course of my experiments, is also of importance, viz., that the antiseptic is used up in killing the bacteria, and that if we have a large number of bacteria in the wound we must use a correspondingly large amount of the antiseptic, quite apart from the medium in which the bacteria are present. I

have not space here to detail the experiments which led me to this conclusion; but, after all, it is only what one would expect.

The strength or concentration of the antiseptic is an important point. The more concentrated it is, the more rapid is its action; while the weaker it is, the slower the action, till a point is reached where, though it may inhibit growth and, indeed, lower the vitality of the organisms, it fails to kill them. I believe the best and most thorough result is obtained by using only a moderately strong concentration, and allowing it to act for some time. This, however, renders it necessary to make provision that the antiseptic can remain in the wound for a considerable period and continue its action. To syringe out a wound even with a strong antiseptic, and then leave it alone for some hours, is quite futile; the antiseptic has not time to act before it runs out of the wound, nor is there any certainty that in syringing a wound the fluid will reach all parts. Hence my suggestion of the use of pastes, which would lie about the wound and continue to act, or of opening up the wound and rubbing in an antiseptic powder. As regards fluids, continuous irrigation, if the fluid passes all over the wound, would do what is wanted; but that can rarely be practicable at the front. Carrel and Dakin have, however, devised what promises to be a very efficient method of employing fluids, which will be referred to presently.

It must not be supposed that an antiseptic introduced into a wound and left there is either altogether washed out with the discharge, or that it lies there waiting to act on any bacterium that comes its way, and that in the latter case the wound must therefore be filled up with the antiseptic in order to make sure that all the bacteria in it will be reached by the drug: this is necessary with fluids, but not with solids or semi-solids. The report of the Naval Medical Committee amply proved that the various antiseptics in ordinary use not only followed the ordinary physical laws of diffusion, but were able to arrest the growth of bacteria, or even to kill them, at a considerable distance from the original deposit, and that in a comparatively short time. And this was the case not only in such material as nutrient agar and gelatine, but also in blood-clot and dead tissues. These facts were absolutely proved, and cannot be truthfully denied.

But not only do antiseptics diffuse through dead or inert tissue; they also penetrate into the living tissues. I admit that until recently this was only a deduction on my part from several observations and from clinical results; and against this view has been urged the idea that the flow of serum from a wound which commences immediately after the injury (I may say incidentally without the use of any hypertonic material) would wash away the antiseptic and would entirely prevent any diffusion into the tissues. At first sight this might seem a strong point, but it does not allow for the remarkable strength of osmotic pressure; and besides, we have against it the fact that poisons put into a wound are very quickly absorbed in spite of the outflow of serum. We are now investigating the facts of the matter. It is by no means easy to devise experiments which will satisfactorily test the question; but I may mention two preliminary trials which Mr. Edmunds made before he left Chatham. These experiments were done with borsal (salicylic and boric acids in equal parts).

A guinea-pig was anæsthetized, and the skin over the left thigh and hip was thoroughly shaved and disinfected. A long incision was then made through the skin, and carried some distance into the gluteal muscles; as much borsal as possible (about 0·1 gram) was then introduced into the wound. The skin incision was closely stitched up, and covered by wool and collodion.

At the end of twenty-four hours the animal was killed, and the skin carefully reflected over the wound. A block of the muscle with the wound in the centre was then cut out, going right down to the bone, and this block was at once turned upside down on the plate of a microtome and frozen; in this way the wound in the muscle with the blood-clot in it was at the lowest part of the block, and the muscle outside the wound was above it. Serial sections $\frac{1}{10}$ mm. in thickness were then made, each section being placed in a numbered watch-glass, and about forty sections were made before the clot in the wound was reached. The thickness of the tissue outside the wound was thus 4 mm. in the frozen state, and possibly a little more normally. Two or three drops of distilled water were placed over each section to dissolve out the salicylic acid, and then a drop of ferric chloride solution was added to each.

In this case no salicylic acid reaction was obtained, and there was no evidence of the acid either in the tissues or blood-clot. At the same time the urine in the animal's bladder gave a strong reaction, and was evidently highly charged with salicylic acid.

I must say that this result surprised me; there had been no discharge from the wound, so that the acid could not have been washed away. Had it all been absorbed, therefore, as the urine seemed to indicate? Or had it entered into combination with the clot or the tissues, and did this compound not give the reaction with ferric chloride?

To test the latter point, some blood was mixed with borsal and kept for twenty-four hours. When tested, both immediately after mixing and also after the twenty-four hours, the salicylic acid reaction was quite strong. Hence the only conclusion was that all the acid had been absorbed.

A second experiment was therefore made in the same way as the above, and the animal was killed after three and a half hours. Sections were made and treated in the same manner as above. In this case thirty-eight sections were made before the blood-clot was reached, or a distance of 3·8 millimetres: of these the outer ten sections gave no reaction with ferric chloride, but the remaining twenty-eight did, the reaction being naturally stronger as the centre was approached.

This experiment shows that at the end of three and a half hours salicylic acid was still present in the tissues to a depth of 2·8 millimetres. The urine in the bladder was already highly charged with salicylic acid.*

As a matter of fact, such experiments are hardly necessary, as we know from clinical experience how readily chemical substances are absorbed from wounds. Even if a wound is merely washed out with a strong solution of carbolic acid, some people will pass olive-coloured urine; while no one would ever think of putting morphia, strychnine, or any other strong poison into a wound, however free the discharge of serum was.

Endeavour to picture what absorption means. It is not a case, as John Hunter imagined it, of the lymphatic vessels having mouths like those of

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* Since this was written I have performed a similar experiment with borsal, the animal being killed after one and a quarter hours; in this case the chemical reaction was obtained to a depth of 3·5 millimetres.

the infusoria, with which material is sucked up and passed on at once into the large lymphatic vessels. It is a case of osmotic pressure, as a result of which the material in the wound passes into the lymph spaces which penetrate the tissues in all directions, and travels on in them till it reaches a large lymphatic vessel, when it is rapidly carried on into the blood-stream; if the tissues have been badly bruised, the circulation in the lymph spaces will be slower, and the antiseptic will have to travel further in the tissues before it gets into the larger lymphatic vessels. While so travelling, any bacteria which the antiseptic comes across will be, so to speak, paralyzed, and ultimately killed if the antiseptic is sufficiently concentrated and remains long enough in contact with them. As a matter of fact, it suffices if we delay the growth of the bacteria and injure their vitality to some extent; for this delay enables the tissues to assemble their forces (chiefly cells), and if the bacteria have been damaged they are very quickly disposed of by the phagocytes.

It has been asserted that antiseptics introduced into wounds interfere with or destroy the leucocytes and other defensive arrangements of the body. That is quite likely as regards the leucocytes, etc., which get into the cavity of the wound; but the experiments just mentioned show how quickly such an antiseptic as borsal is absorbed from the wound. I have been very much struck, when searching blood-clot for bacteria from wounds into which borsal had been introduced twenty-four hours previously, with the large number of leucocytes already present in the clot; but we now know that by that time probably most, if not all, of the antiseptic has gone, and of course aseptic clot is a very favourite hunting ground for leucocytes.

PRINCIPLES OF DISINFECTION.

The above are some of the chief points about antiseptics which it is well for the surgeon to bear in mind in approaching the disinfection of a wound. Now I must say a few words as to the practical application of Lister's work.

There are four points of the greatest importance in carrying out the disinfection of a wound: (1) *The surgeon must believe that such disinfection is possible;* (2) *He must choose a suitable antiseptic;* (3) *He must see that the antiseptic has free access to every part of the wound;* and (4) *He must arrange in some way or other for the antiseptic to remain in the wound for some time, so as to obtain a continued instead of a momentary action.*

1. The surgeon's belief in the possibility of disinfecting a wound. This is, of course, self-evident, and I would not have mentioned it were it not that the possibility of disinfection has been 'investigated' in France by men who had previously expressed the opinion that such disinfection was impossible and would do more harm than good. It is not an easy matter to disinfect a wound; and if the surgeon does not believe that it can be done, he is not likely to carry it out very thoroughly, especially if he is afraid that he may do harm.

2. The choice of an antiseptic. As long as it was considered necessary that the bacteria should be killed at once by a single application, one

had to choose an antiseptic which would act quickly and in sufficient concentration, bearing in mind the fact that all antiseptics lose a very large part of their power in albuminous solutions. Indeed, some antiseptics, such as iodine and corrosive sublimate, especially the former, combine so firmly with albumin that they are of little use in disinfecting wounds. Until this war, I had, as a rule, aimed at the immediate destruction of bacteria in compound fractures and accidental wounds; but I have always recognized that all the bacteria may not be killed at once, and have regarded the application of undiluted carbolic acid to the raw surface as a means of providing a store of antiseptic, or, as I expressed it, of 'pickling' the wound, so that the acid should go on acting and gradually killing the bacteria which escape in the first instance, or at least so badly injuring them that they readily fall a prey to the phagocytes. Since taking up experimental work again last year, I have learned much about antiseptics, especially about their diffusion and action on bacteria, and I do not now insist so much on the antiseptic being chosen and its strength determined from the point of view of rapid destruction of bacteria. I believe that so long as the growth and activity of the bacteria can be rapidly inhibited by the antiseptic, it does not matter whether actual death of the bacteria takes place in two minutes or two hours, or even longer; and further, that in some cases the disinfection will be, as I have just said, completed by the action of the phagocytes on those bacteria which are damaged but not killed by the antiseptic.

Hence it is quite possible that a variety of antiseptics will give a satisfactory result so long as they are properly employed on the principles enunciated below. I shall presently give a few examples of the results with several different antiseptics.

3. The surgeon must see that the antiseptic has free access to every part of the wound. This means in most cases, certainly in perforating and deep wounds with a comparatively narrow track of entrance, the thorough opening up of the wound, so that all its recesses are freely accessible, and as far as possible visible. This involves an anæsthetic, and the wound must be opened as thoroughly as the anatomical conditions, and the state of the patient as regards shock, permit. Success or failure will mainly depend on the thoroughness with which this is done. If possible, the circulation should be arrested for the time; and not only must the skin be freely incised, and usually the edges of the wound excised, but a careful dissection of the deeper parts should be made till, with the aid of retractors, the whole injured area is exposed to view. In the course of the dissection, bruised, torn, or soiled portions of tissue should be removed. The further procedure depends on the antiseptic employed, and on whether immediate disinfection is aimed at or not. In any case, I believe it is well to do as much as possible in the first instance in the way of killing the bacteria. I discussed this point with Dr. Dakin as regards the hypochlorite solution, which is of about $\frac{1}{2}$ per cent strength, and he quite agreed that the wound might with advantage be swabbed out with a 2 per cent or even a 4 per cent solution in the first instance, and then the weaker solution employed in the usual manner. I have indeed thought that in badly soiled cases it might be well to apply borsal powder freely in the first instance, arrange Carrel and Dakin's tubes and gauze at the time of the operation, and

start the hypochlorite treatment after twelve to twenty-four hours. However, this is only a suggestion.

It is as regards the thorough opening up of the wound that surgeons are most apt to go wrong. A man who is not very much accustomed to surgical work makes a valiant incision through the skin, and then, after a little deeper dissection, loses courage, lays aside his knife, and tries to dilate the deeper parts by stretching them with his fingers or with instruments. This does not give satisfactory exposure, and cases dealt with in this way are very apt to fail.

In some scooped-out shell wounds or superficial lacerated wounds, it may be unnecessary to enlarge the wound; but soiled and ragged pieces of tissue should be clipped away, and, in both these and the former cases, the wound should be thoroughly cleaned out before the application of the antiseptic.

After the antiseptic has been thoroughly applied, arrangements for free drainage must be made, and all other ordinary surgical procedures attended to.

4. The surgeon must arrange for some of the antiseptic to remain in the wound for a considerable time, so that it may continue to act. In the case of powders, it will suffice if they are well rubbed into the surface and some excess of powder left behind in the wound. Powders may also be made into pastes with various bases, and so may various liquids; the pastes should be well rubbed into the surface of the wound, and little deposits of the material left here and there over the surface. In both cases it is well to put in drainage tubes. Carrel and Dakin have also shown that a constant action of fluids may be kept up apart from constant irrigation, which is for the most part impracticable at the front: their method is to use small drainage tubes with lateral holes covered with Turkey towelling, or naked tubes surrounded by light gauze packing; these are inserted to the depths of the wound and all the recesses, and then several cubic centimetres of the hypochlorite solution are injected with a syringe every one or two hours. The result is that there is a constant supply of the antiseptic solution in the wound, the lotion being renewed before the former supply has been altogether washed away.

RESULTS.

I may now give a few samples of the results obtained with the antiseptics of which I have so far had experience in this war, viz., carbolic acid, cresol, borsal, and hypochlorite of soda.

In a paper which I was asked to read at the Medical Society of London in October, 1914, on the treatment of wounds in war, I described Lister's final method of disinfecting compound fractures, and made the suggestion of a freer use of undiluted carbolic acid in the above wounds. The plan I advised had worked extremely well in my hands in civilian practice, and I had had many aseptic cases with it; but the opposition to Lister's plan was so great, that it very soon became evident that if I insisted on it as the only method, nothing would be done.

Following this meeting, I sought to find some plan of delaying sepsis at the front until such time as the wound could be disinfected; and this matter was investigated by a Naval Medical Committee consisting of Fleet-Surgeon

Bassett-Smith, Mr. Arthur Edmunds, and myself. We suggested, for preliminary trials, pastes containing carbolic acid or cresol and borsal powder. As is no doubt well known, our recommendations were 'investigated' by the Army Medical Corps in France, who had these pastes squeezed into wounds and left there, but made no subsequent attempt to disinfect the wounds, as they ought to have done. The result was that, in some cases, the clot which formed in the part of the wound which the paste reached in sufficient quantity prevented the escape of the discharge from the deeper parts where none or only a small quantity of the paste had penetrated, and thus abscesses and sepsis occurred in these parts. As a result, they dropped it like a hot potato; not only so, but they prohibited the use of any of our recommendations at the front. In their enthusiasm to root out this heresy, they in one case prohibited the use of a borosalicylic paste which did not exist!

I should like to consider this matter a little further. The great point that struck these investigators was, that firm blood-clot formed in the outer track of the wound which was reached by the paste. Now this fact should have set them thinking, and if they had done so, they would have seen that they were faced with something new in their experience. It is an indisputable fact that if blood-clot becomes septic it becomes soft and diffluent, and is very soon discharged from the wound. On the other hand, if the clot is aseptic it remains firm and adherent to the sides of the wound—in fact, we get what I have termed 'healing by blood-clot.' Now when they saw this firm blood-clot, they should have said: 'We have here something which we have not been getting previously in these wounds, viz., aseptic blood-clot. How is this? Why does the deeper part of the wound become septic in some cases?' The natural answer was that while the paste had led to a deposit of aseptic clot in the parts which it had reached, sepsis occurred in the deeper parts to which the paste had not found satisfactory access; and instead of stopping the use of the pastes, they should have got busy opening up the deeper parts of the wounds and working the paste into all the recesses.

The fact that the carbolic and cresol pastes alone can render some wounds aseptic if only they are applied to the whole wound surface, e.g., compound fractures, was mentioned by me in the Hunterian Oration, and my experience still remains the same. In my paper in the *Lancet* of July 31, I referred to similar experiences by Mr. Edmunds in shell wounds: in many of these the whole wound is lying freely open, and the paste can be thoroughly applied. I quite admit that I have never liked the large proportion of beeswax in our basis, and I think 5 per cent of wax would suffice quite well; but in that case the strength of the cresol would need to be reduced to 10 or 15 per cent, as it is the wax which prevents its irritant or caustic action.

In the course of our researches we found that a powder consisting of equal parts of boric and salicylic acids, which we termed borsal, was very energetic in protecting guinea-pigs from infection from earth containing large numbers of tetanus and gas-gangrene bacilli, and we therefore included it in our preliminary recommendations, and mentioned cases treated by it. I have done a good deal of work with borsal, and have the greatest faith in its powers. The following is a very remarkable case illustrating the value of borsal in septic cases.

A boy, age 15, was admitted into the medical wards at the Royal Naval Hospital, Chatham, with a temperature of 104·4° and râles at the bases of the lungs. No definite pneumonia, however, developed, but he began to complain of pain in the left ear; the temperature remained irregular, and after some days there was a purulent discharge from the ear. About this time he began to have pain in the right calf, and in a week the symptoms became more acute and the temperature rose to 105°. The boy became very ill, the pulse was 136, and the temperature kept up; three days later he was transferred to the surgical department. As it was evident that the boy was suffering from acute osteomyelitis of the right fibula, operation was at once performed.

The operation consisted in a long incision over the outer side of the fibula at the upper part, where I opened a large abscess, and found the bone bare on its outer side. I then chiselled into the medulla and found it full of pus. The incision was therefore extended down to the lower end of the bone, the medulla was laid open throughout its whole length, about one-third of the circumference of the shaft was removed, and the medullary canal, which contained pus throughout its entire length, was thoroughly scraped out. The infection had not spread into either epiphysis. I now took some borsal powder, and with a spatula filled up the medullary canal with it from top to bottom. I then rubbed the whole surface of the wound with the powder, especially vigorously where the abscess was, took three good-sized drainage tubes, rolled them in the borsal, introduced them, one at the upper part, one at the lower, and one in the middle, right down to the bone, and stitched up the whole wound, only leaving room for the exit of the drainage tubes. The organism was the *Streptococcus pyogenes*.

Following the operation the boy's temperature fell at once, and he rapidly recovered. There never was any suppuration from the wound, all the stitched parts healed by first intention, and the drainage tubes were left out on the tenth day. The openings from which they were removed became covered with scabs, which dropped off later, leaving a scar beneath.

I had to leave Chatham a week after the operation; and when I returned about three weeks later, I asked for the boy, and was told that he was quite well and walking about!

Now I ask any surgeon who reads this account to consult his experience and say whether this is not something new; certainly in my experience it is. I hope, however, that I will not be held to be recommending this as the treatment for osteomyelitis in preference to the ordinary surgical measures; but it is a very extraordinary and unique case, and is, I consider, a very remarkable testimonial for borsal.

I asked Mr. Edmunds to write out for me three cases from his list, bearing on the question of disinfection of wounds in war. He has sent five, which I append, and which I hope will be read and studied.

Case 1.—**Perforating bullet wound of the skull. Disinfection with strong mixture. Trephining. Aseptic healing.**

A lieutenant in the R.M.L.I. was hit in the head by a bullet at a range of 1000 to 1500 yards. He had no paralysis or sensory disturbance, but he was a little inclined to be garrulous.

The bullet entered in the right anterior parietal region, passed downwards to the base of the skull, entered the mouth, where there was a small wound just above the right tonsil, passed across the floor of the mouth, and lodged in the left submaxillary triangle, whence it was removed.

The wound of entry was small, and of the type which I have christened a 'brain-boil'—i.e., there was a small conical swelling, from the apex of which pulped brain substance was oozing.

An anæsthetic was given, the skin shaved, and the wound excised by a couple

of curved incisions, from the junctions of which cuts were continued downwards so as to form a small flap.

The wound was thoroughly swabbed out with Lister's strong mixture (i.e., 1–20 carbolic lotion in which a sufficient quantity of corrosive sublimate is dissolved to form also a 1–500 sublimate solution), and a ¾-in. trephine applied to one side of the opening in the bone, so as to give access to some depressed splinters. These were removed, the wound was again swabbed out with the strong mixture, and then sutured, leaving a small tube for drainage.

The brain substance oozed for forty-eight hours, at the end of which time the tube was removed and the wound stuck together.

All dressings were left off in thirteen days. There was no suppuration, swelling, or local disturbance of any kind.

Case 2.—**A case treated on the beach at Cape Helles with cresol paste, and subsequently operated on. No time was noted, as the patient was unconscious; but probably he had been wounded about eighteen to twenty-four hours previous to his admission.**

Lieut. R.N.V.R. Injured June 28. Operation next day. He was brought on board with a small wound about one inch long by half an inch wide over the left parietal region. The wound was a ragged lacerated one which did not expose the bone, but the tissues of the scalp around it were extensively bruised and swollen.

The wound itself was full of cresol paste, which, I believe, was put in immediately after the injury. The cause of the wound, I ascertained later, was a shrapnel shell which exploded over his dug-out; the time fuse struck his head as he was resting.

He was obviously suffering from 'compression,' and a large depression could be felt in the skull. The wound was excised, a large flap turned down, and an extensive operation performed, everything being carefully cleaned out with strong mixture.

The operation consisted in removing several pieces of bone, elevating two large loose flakes, ligaturing a branch of the middle meningeal artery, and making two small incisions through the dura to see whether there was any intradural hæmorrhage. The extent of the depression was about three-quarters the size of the palm of the hand. The scalp was sutured and a tube put in, which was removed on the third day.

He had severe cerebral symptoms, from which he tardily recovered; but the wound healed quite as readily as in a set operation.

I cannot but feel that although I undoubtedly helped this result by excising the wound, had no antiseptic treatment been employed there would undoubtedly have been some sepsis, at least in the bruised tissues of the scalp; and in view of the extensive bone injury there would have been a fair probability of necrosis of the detached flakes, which were about 1 inch by 2 inches in size. Further, I believe the early application of the paste made my operative treatment possible, as it checked any initial infiltration of bacteria into the bruised tissues.

Case 3.—**A wound disinfected by cleaning out with strong mixture, and then treated by squeezing paste into its depths and powdering superficially with borsal.**

C., a New Zealand officer, was struck by a shrapnel bullet over the lower part of the right deltoid region, on May 19, 1915. The ball passed through the humerus, splitting it at a point about two inches below the head into a bunch of longitudinal fragments.

Sixteen hours after the injury was received the wound was opened through an anterior incision and well swabbed out with strong mixture. The ball was removed, and to keep the fragments more or less together, a silver wire was bound round them, fastening the ends of the bone and the splinters together somewhat after the fashion of a faggot.

The cresol paste was next injected among the fragments, and the muscles dusted with borsal. The wound was sutured, except for a space left for a drainage tube. The latter was removed three days later.

The sutured portion of the wound healed quite naturally. There was a certain amount of discharge through the tube opening, but this was merely the blood, acted

upon by the borsal, etc., which had been softened by exuded serum and come away. There was never any suppuration, inflammation, or necrosis of bone during his stay on the hospital ship [*Soudan*]. I met him about a month after his injury, and he told me that the opening for the drainage tube healed quite readily, and that he was beginning to get use in his arm.

Case 4.—**Severe lacerated wound of the forearm, with comminution of the radius and fracture of the ulna.**

This patient was received three hours after injury. He had a large open wound, extensively soiled, in the forearm. The hand being limp and helpless, my first impulse was to amputate the limb.

However, I thought I would give the hand a chance ; so I thoroughly scrubbed out the wound with strong mixture, injected paste between the bone fragments in the depths of the wound, and powdered the surface with borsal.

We had him under observation for five to six days, ample time for suppuration to become established ; but this never happened. In the large wound, with powder and clot at the bottom, there was an absolute absence of any swelling or smell. The arm was painless, and the patient was able to be up and about the ship in a couple of days.

Case 5.—**Illustrating the use of paste.**

A. B., R.M.L.I., wounded in trenches on June 10, at 11 p.m. The bullet entered over the anterior superior iliac spine on the right side, passed forwards and to the left through the substance of the anterior abdominal wall, and made a large hole in the epigastrium, not involving the muscles, about two inches in transverse measurement and one inch in the longitudinal direction. Paste was injected while the patient was still in the trenches. His wound received no further disinfection, and granulated up readily without any suppuration or spread of infection along the track.

I need not multiply cases ; but I may mention another, where the patient had many bomb wounds all over the body, the worst being on the face and forehead. Those on the face were treated with borsal, and remained aseptic both clinically and bacteriologically ; the rest were treated with wet hypochlorite cloths, and most of them suppurated. It was not really a suitable case for hypochlorite treatment ; but it again shows that, the lymph being the same in all the wounds, the difference in asepticity was due to the antiseptic and not to the lymph.

I have recently had the opportunity of seeing a few cases treated with hypochlorite, but owing to various circumstances I only treated two myself. One of these was a bullet wound through the knee-joint, which I opened up freely, and irrigated the knee as well. The joint was full of blood and air, which I squeezed out, and then enlarged the opening into the joint. This case did perfectly well, and was absolutely aseptic both clinically and bacteriologically ; when he left us a fortnight after the injury, there was only a small superficial granulating wound, and the joint was freely movable. The other, a shrapnel wound of the thigh, which was opened up and, after removal of the bullet, treated with hypochlorite, was also aseptic. Four other cases, two of them compound fractures, were also successful. The remainder, however, were for the most part imperfectly opened up, and the hypochlorite was only renewed every four hours ; most of these had temperature and local sepsis for three or four days, but no spread of the infection, very little pus, and, in several, only very few organisms in the smears. I gained the impression that the hypochlorite treatment, properly applied, was very promising, and in various ways might

supersede other methods; but like other antiseptics, it must gain free access to the part, and as it is a liquid it must be frequently renewed.

In this paper it is not my aim to estimate the relative position and value of various antiseptics, nor the exact methods in which they should be used. Suffice it to say, that I believe that with carbolic acid, cresol (in watery solution and in pastes), borsal, and hypochlorite, the surgeon has at the present time at his disposal a variety of substances which, properly employed, will enable him to obtain aseptic results in a considerable proportion of cases. I do not overlook the various difficulties in disinfecting these wounds; but difficulties ought only to spur one on to devise means of overcoming them; and I think I have produced sufficient evidence to show that Sir Almroth Wright is not stating the fact when he says that antiseptics have completely failed to produce aseptic wounds in war.

I have said nothing of a matter in which I have been much interested, viz., temporary treatment in the trenches in order to delay the spread of the infection till the wound can be properly attended to. I have not omitted this because I am any the less convinced of its great importance, but because there seems no chance of any one trying to work it out, and I can say no more than I have done. I should have liked to have seen a paste of borsal tried; and I have made a mud of borsal and glycerin, and filled up wire tubes with it such as are used for draining the antrum or for introducing medicaments into the uterus under the name of antrophores. These were suggested to me by Dr. Foulerton; they could be rapidly pushed deeply into the wound, coiled up there and left, and could be readily pulled out when the patient reached the dressing station. So many combinations and methods occur to one, that it is most disappointing that no surgeon will try to work them out, especially as I feel certain that here is a gold mine only awaiting development.*

TREATMENT DEPENDENT ON THE SUFFICIENCY OF THE DEFENCES OF THE BODY TO OVERCOME THE INFECTION.

Those who belong to this school of thought do not consider it possible to disinfect a wound with antiseptics, in fact they do not believe statements

* Since the above was written I have had the pleasure of listening to Sir Anthony Bowlby's Bradshaw Lecture on the treatment of wounds in war. With much of what he said I am in full agreement, though I would not go so far as he does in the advocacy of antiseptics in suppurating cases. Indeed, I cannot say that I have been able to identify any particular benefit in these cases from the use of antiseptics, with the exception of peroxide of hydrogen. (I have not yet had sufficient experience of hypochlorite to speak with regard to it.) But in listening to his lecture, the importance of the early treatment, even if imperfect, to which I refer above, was more than ever impressed on me. A patient is wounded after perhaps a long exposure to a heavy bombardment. He is brought in collapsed, often asleep and not easily roused, not suffering much pain, and not in a suitable condition for prolonged anæsthesia and thorough opening up and disinfection of his wound. All that it seems possible to do as regards the wound, without some such expedient as I have suggested above, is to put on a clean dressing and a bandage, to make him comfortable, and attend to the shock, and wait until he recovers, which may not be for several hours. In the meantime the bacteria are growing and getting a firm hold on the wound, and by the time the latter can be properly attended to it may be too late, and the mischief be done. Surely it is most important to find some means of delaying the infection under these circumstances. I am afraid that fatal 'too late,' of which Mr. Lloyd George has been speaking so much recently, is too often true of the attempts at disinfecting these wounds, if, indeed, proper attempts are ever made.

such as those which I have made above; they have not had experience of the kind themselves, and they place all their reliance on the resisting power of the body. They believe that the exudation from the wound will carry sufficient antibacteric substances with it to prevent the development of the infective organisms; or if not, they think that by increasing the amount of discharge by the introduction of irritants into the wound, or by increasing the potency of these antibacteric substances by the use of vaccines, this result ought to be obtained. Unfortunately, they have so far obtained very insufficient clinical or bacteriological evidence in support of this hope.

That the living tissues have an enormous power of protecting themselves against the assaults of bacteria is self-evident: otherwise, indeed, animal and vegetable life would be impossible. Lister was probably the first to demonstrate this fact, and it was an important article of faith with him, and influenced his work very much. He showed that bacteria could not spread up glandular canals, such as the urethra, milk ducts, etc., so long as the mucous membrane was healthy and intact, and that urine and milk could be received and kept in sterile flasks for an indefinite time without the development of bacteria, provided that the external orifices of these canals were in the first instance thoroughly cleansed and disinfected. He also showed that healthy blood could be preserved in sterilized flasks indefinitely without decomposition. In this connection he observed the very curious phenomenon that, if the blood were drawn aseptically into a glass flask which had been sterilized by heat, the clot which formed did not contract and squeeze out serum, as is the case when blood is received into an ordinary non-sterilized glass vessel. This corresponds to what takes place in aseptic wounds, where the blood-clot does not contract, but remains firmly adherent to the sides of the wound so long as it is aseptic. I fancy that the bacteriologists are not familiar with this fact; otherwise they would not have complained of the clot which remained in the wounds treated by antiseptics, as if it were a bad thing, instead of being a most promising phenomenon.

Now, in connection with these blood-clots in flasks, Lister found that in order to obtain bacterial growth, it was generally necessary to introduce a considerable number of bacteria, and that if only a single bacterium or a small number were introduced, they often failed to grow, and indeed died out. This was the first suggestion that there was such a thing as a dosage of bacteria, and it was this unexpected fact which led me to undertake an investigation in order to see whether there was any question of dosage of bacteria in connection with disease in the living body. The result of my work was to establish the principle of the relation of the dosage of bacteria to the occurrence of infection, and to show that not only the production of a disease, but also its severity, bears a definite ratio to the initial dose which is introduced. From these experiments I drew various conclusions, of which I may mention the two following:

1. *The pathogenic dose of a virus varies inversely with the predisposition of the animal to the disease in question.*

2. *In animals not very susceptible to a particular disease, the severity of the affection varies directly, within certain limits, with the amount of virus introduced.* In such cases, while a small dose will produce no effect, a moderate

dose will cause only a local lesion, while a large dose will set up a general infection. If these are translated into terms of immunity, their bearing on our subject will be at once apparent, and I shall refer to them again.

I may refer the reader to my original paper, entitled, " Report on a Study of Certain of the Conditions of Infection," in the *British Medical Journal* for July 31, 1886, and also to my Hunterian Lectures on " Suppuration and Septic Diseases," delivered at the Royal College of Surgeons in 1888. Although I perhaps ought not to say it, I think a perusal of these papers, though now nearly thirty years old, would be of assistance to anyone who has difficulty in appraising the practical value of the recent views on immunity and vaccine therapy.

The idea that disease is a battle between the tissue cells and the parasites was long ago upheld by Virchow, and in my book on *Antiseptic Surgery*, published in 1882, I pointed out the great influence exerted by healthy tissues and blood-clot in preventing the development of micro-organisms in wounds.

Again, Lister very early observed the fact that if a fully-developed acute abscess was opened and drained, and if steps were taken to prevent further infection from without, suppuration ceased almost immediately, and, as I have found, the bacteria very soon disappeared from the discharge. The explanation which I gave of this fact in my book, *The Treatment of Wounds, Ulcers, and Abscesses*, published in 1894, might have been copied from Sir A. Wright's papers at the present time. " As the result of opening the abscess, a quantity of serum is poured out, which in part sweeps away the cocci, and in part destroys them, as the result of the largely increased amount of anti-bacteric material which is thus brought in contact with them." And in my Harveian Lectures for 1899, " On the Treatment of Tuberculous Diseases in their Surgical Aspect," I gave practically the same explanation of the good results which sometimes follow operations for tuberculous peritonitis.

I mention these facts, not from any vainglorious motives, but in order to show that neither Lister nor his pupils have been in any way opposed to the present views on immunity, but that on the contrary they entertained similar views from a very early period of their work. Hence, if I criticize Sir A. Wright's vaccine therapy and his theories on wound treatment unfavourably, it is not because I have any prejudice against such views, or look on them as in any way antagonistic to Lister's work. My criticism is founded on my strong conviction that Sir A. Wright is going much too far with these views, and asking the body to do a great deal more than it is reasonable to expect of it.

There are evidently several fallacies at the bottom of Sir A. Wright's work, otherwise he would get clinical results which he could show us; and I believe the most important lies in the false impression which is conveyed by the words 'immune' and 'immunity.' If we say that an animal is immune against a certain disease, one would naturally assume that it could not catch that disease, however much it was exposed to the virus ; and so, when we speak of a patient's immunity, we are apt to think of a complete immunity. But such a thing as complete immunity is quite rare ; much more commonly it is a relative immunity. Take, for instance, human beings and tubercle; the degree of immunity varies, but very few people have absolute immunity ; the great majority of those who are apparently immune will develop the disease if they

get a sufficiently large dose. Wright's opsonic index is only an index of the average degree of immunity which the human species possesses against an individual organism, but it is not the case that a patient possessing this average degree of immunity cannot be infected; still less is this true regarding most of the organisms which produce septic diseases. Hence, it does not follow that, when the opsonic index has been raised to normal, the organisms must die out; nor does it follow, when antibodies of the degree of potency normal to the human being are poured out into a wound, that the bacteria which come in contact with them must necessarily be killed. This will certainly not be the case if the patient has received a large dose of bacteria. In reality, immunity is a very variable thing, depending on various conditions of the body, and, perhaps most of all, on the primary dose of bacteria. I think that people have been forgetting that immunity is only a relative term, and are expecting too much from it in the prevention of disease.

Let us consider the suggestions which are made in the recent paper by Sir A. Wright for the treatment of wounds on the basis that the body must protect itself from the invasion of bacteria. I have not space to criticize the paper in detail, but content myself with a general review of his suggestions. I need not go into the old and well understood surgical measures which are also referred to, viz., cleansing wounds, opening them up, free drainage, constant irrigation, and secondary suture (or union by granulations, or by second intention, as it is termed in some of the older books). I may however suggest, in passing, that in the case of irrigation the old plan of using thick threads or skeins of wool to convey the fluid to the interior of the wound will work much better than strips of bandage. I may also remind the reader that water-baths and constant irrigation were used extensively in the Schleswig-Holstein campaign in 1866—and the surgeons were very dissatisfied with the results. As regards secondary suture, that is also an old plan, especially in amputations, and it is one which is still employed in some cases to shorten the healing of wounds. I do not know if Sir A. Wright has tried to carry it out in other cases than amputations where the flaps are long and have been left unstitched; but if he has, he will admit that it is by no means an easy task, and can really only be done in quite a small proportion of the cases. Not only is it not easy, but it is not very safe to open up fresh tissues to infection, however slight the infection in the wound may appear to be. It is not a surgical measure to be lightly or generally recommended.

When these established plans are omitted, what remains? Frequent or constant irrigation with salt solutions of various strengths, and the use of vaccines. And what are the results? There is no mention of them. The author discusses the antibacteric power of the body, on data obtained chiefly by capillary-tube experiments, which are not at all convincing; but I fail to find any data founded on clinical results.

In a former paper published last spring, Sir Almroth Wright laid great stress on the value of a strong solution of salt, which he spoke of as hypertonic salt solution, and at that time there was no mention of serious disadvantages. However, it seems that the solution is not quite innocuous; and it is now referred to as a phylacagogic agent, and more especially as a lymphagogic one. All these new names are very ingenious, and have a highly scientific

flavour; but they are confusing, and simply express a theory which by constant reiteration is apt to become looked on as a fact. I always think it is better to employ names in common use, which do not involve a theory and merely indicate what we are working with. Now the common name for strong salt solution is 'brine,' and that is surely a much more useful designation than a 'phylacagogic agent.' As a rule the strength of the brine which Sir A. Wright uses is 5 per cent, but in sloughing wounds and in those with insensitive granulations he raises the strength up to 10 per cent. Above that he finds that the patients cannot bear the pain. I have heard from various surgeons that they were not at all satisfied with the results of even the 4 to 5 per cent brine, and I must confess that it has not appealed to me as an application to wounds. As a matter of fact, some of the worst septic cases which I have seen since the war commenced have been in sailors who had been immersed in the briny ocean for some time after the infliction of the wounds. In such cases, especially in large open wounds, the salt water had free access to the wound from the very first; and what struck me, long before I knew that Sir A. Wright was so insistent on the value of brine and sea water, was that even when the patients were received into the hospital only a few hours after the injury, their wounds were already exceptionally highly septic.

Brine is, of course, well known as a preservative agent, and in strong solutions nothing will live in it. In wounds treated for some time with 5 per cent brine, we are told, however, that, though most bacteria have disappeared, streptococci and some staphylococci can still be found. But it was not as an antiseptic that brine was first introduced; it was with the idea that by osmosis the lymph containing antibacteric substances would be drawn from the vessels and fill up the wound in such large amount that the bacteria would be destroyed. It is, however, a well-known fact in physics, that the interchange between colloid and crystalline substances is very slow and incomplete; and although Sir A. Wright still tries to defend his physics, there is no doubt that any osmotic effect which would be produced by the introduction of brine into a wound would be chiefly the transudation of large quantities of water from the blood. At the same time, I have no doubt that the presence of brine in a wound does lead to a marked increase in the discharge, which will contain a considerable amount of proteid material—derived, however, not by osmosis from the blood, but from the irritant action of the salt on the tissues.

But, the result of filling up a wound with brine being an exudation of lymph—no matter from what source—containing a large amount of the natural antibacteric substances, the question arises: What will happen to these substances when they come in contact with the brine? Presumably they are delicate proteid bodies, and I should have thought that they would have been immediately destroyed or rendered inert by the excess of salt. According to Sir A. Wright, something of that kind does happen to the leucocytes, but apparently the point has not been investigated; at any rate I can find no mention of experiments on the matter. I think we must take it however that brine containing 5 to 10 per cent of salt has the double disadvantage as an application to wounds in that, on the one hand, it is injurious to the protective mechanism of the body, and on the other, is not a sufficiently powerful antiseptic to disinfect the wound completely.

Since Sir A. Wright published his recommendation of brine of 5 per cent strength last spring, he has evidently had clinical experience that it is not a good application to wounds; and he shows by experiments that it exercises a pernicious influence on the protective arrangements of the body. He shows that in blood-clot, brine has a negative chemiotactic effect on the phagocytes—i.e., instead of attracting them to the point where they are required (positive chemiotaxis) it repels them, so that the clot in the neighbourhood of the salt has no phagocytes in it except those which could not get away in time, and these are either paralyzed or destroyed. Isotonic salt solutions have, on the contrary, the opposite effect. The same thing apparently occurs in wounds as in the laboratory experiments, and his description of its effect on the former is very illuminating. He says, speaking of wounds which have been treated with brine, that although there is " a wonderful improvement upon the state of the wound before treatment, none the less the prospect for the future is not quite reassuring. In point of fact, we have here lying open and naked before us all the lymph spaces; and, moreover, the elements of the lymph are disposed in the kakotropic arrangement—the fluid elements which furnish a favourable culture medium in front, and the leucocytes which would be capable of combatting the streptococci behind. *And, at any rate, so far as the superficial lymph spaces are concerned, there would now seem to be nothing to prevent microbial invasion, save only that we have here an outflowing current.*"* An outflowing current! As if that would make any material difference to the penetration of bacteria into the tissues!

Let us now consider Sir A. Wright's recommendations for the treatment of these infected wounds. They are divided into four stages:

1. Irrigate the wound diligently with 5 to 10 per cent brine, and keep this up till the wound has got into the condition described at the end of the preceding paragraph. Having now frightened away the approaching phagocytes and destroyed those within reach, having opened up the lymph spaces, and, in fact, having done a considerable amount of damage, the time arrives when we must try to mend matters, and so we come to the second stage.

2. The brine is to be dropped, and physiological salt solution substituted for it. This is supposed to lead to the migration of the leucocytes into the part, with the result that the number of bacteria in the wound should at first be diminished. But the physiological salt solution must not be continued very long, otherwise things will go badly wrong; for, to quote again, " If events were now allowed to take their course, the leucocytes which had been drawn up to the surface, and in particular, perhaps, those which had done service in the destruction of microbes, would not long maintain their vitality. For the conditions which prevail on denuded surfaces are, as we have seen, uncongenial to leucocytes. Now, just as soon as the first leucocytes die and break up and set free their trypsin, all those in the neighbourhood become involved in the same ruin; and this provides, for any microbes that have survived or come in from outside, an eminently favourable culture medium."

3. When this stage has been reached we must, therefore, " proceed immediately to secondary suture of the wound." It is all very well for

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* The italics are mine.

the bacteriologist to order the surgeon to proceed immediately to secondary suture of the wound! It is more easily said than done, especially as it is not a suture of the skin edges which is required, but a complete approximation of the whole granulating surfaces. It may be possible in amputations with long flaps, but I defy any surgeon to do it after some days in the ordinary types of large gunshot wound; and if he tries, he will on the one hand almost certainly leave a space or spaces somewhere, and on the other, he will open up fresh tissues and expose them to the risk of fresh septic infection. After having performed this secondary suture, the time has now arrived for the next stage, viz.,

4. The administration of vaccines! Having driven away the phagocytes and spoilt the protective arrangements of the body with the brine; having then provided in the wound an excellent pabulum for bacteria by the use of physiological salt solution; having then made an attempt to close the wound by secondary suture, which will more often than not fail: we are now told to inject some more toxins into the body, as if it had not already in most cases got more than it could deal with!

I shall leave my readers to form their own opinion of this method. It seems to me to belong to the class of meddlesome surgery, and to be rather a reversion to the ancient plan of *making wounds heal*, than a continuance of the modern Listerian principle of *leaving the healing of the wound to nature*, and contenting oneself with removing as far as possible all obstacles to healing. The suggestion that surgeons who follow this plan should be associated with bacteriologists, who will show them how to seize the psychological moment for the various changes, seems most admirable and necessary.

But it has been said to me: "It is all very well to criticize these elaborate and difficult researches unfavourably. Sir Almroth Wright's treatment must clearly be successful, otherwise the numerous medical men at the front would not have remained silent for seventeen months." This is quite a natural retort; but I have nothing to do with the actions of the men at the front, and besides, there is such a thing as discipline. I have myself seen cases which have been treated in this way, and the state in which many of these patients reach this country from France is quite sufficient evidence of the want of success of the treatment employed.

But, further, let us again turn to Sir A. Wright's paper, and quote one or two sentences bearing on this point. Towards the beginning of his lecture, he puts the problem thus: "What is here the chance that the defensive mechanism of the body will prove adequate for the destruction of the microbes; and may we reasonably look to see the infection aborted? And in the event of the infection not being extinguished, what kind of course will it shape?" Turn over the pages, and no reference will be found to clinical work, nor any note of cases treated; but, in ending his remarks on vaccines, he says, as regards clinical evidence: "For the present therefore *there is not—nor will there ever be*, except in connection with the last class of case (the abortion of incipient infection)—*anything to carry conviction* to that type of man who puts aside what he calls 'theory,' and demands everywhere proof and certainty."*

* The italics are mine.

Certainly it is a very annoying type of man who wants some evidence before he accepts a statement as correct; but I do think we might have had at least one or two illustrative cases. Instead of that, we have to be content with hypotheses deduced from a number of experiments with capillary tubes; and if the clinical facts do not seem to agree with the hypotheses, so much the worse for the facts.

I have in the preceding pages attempted to state as clearly as possible what it was that Lister did, in the treatment of infected wounds, which completely revolutionized surgery. And in contrast with this I have placed the suggestions which are now being made by those who would leave much to the defensive arrangements of the body.

I would now ask the questions: Had Lister never lived or introduced his system of wound treatment, would the method advised by Sir Almroth Wright have produced a similar revolution in surgical treatment to that effected by Lister? Would there have been the same remarkable pilgrimage of surgeons and scientific men from all quarters of the globe to be instructed in Sir A. Wright's theories with their curious mixture of fact and fantasy, to examine his experiments with capillary tubes, and to see—no clinical aseptic results?

I have a strong suspicion that before long brine will disappear from Sir A. Wright's armamentarium, and that he will be left with his vaccine therapy alone. I have not the space to discuss that question here; but whatever we may think of vaccines in the treatment of disease, I think we are pretty well agreed as to their value as prophylactic agents. Bacteriologists have a very great opportunity at the present time. Let them migrate from France to England, and set to work during the next six months to raise the immunity of the new recruits against all the ordinary forms of bacteria which occur in these wounds. If these men are subsequently wounded, they may either escape infection altogether, or at any rate will very probably develop a less serious form, and one more amenable to treatment. Incidentally, the surgeons at the front might take advantage of the absence of the bacteriologists to try what could be done by more purely surgical methods.

THE BRADSHAW LECTURE ON WOUNDS IN WAR.

By Surgeon-General Sir ANTHONY BOWLBY, K.C.M.G., A.M.S.,
Surgeon in Ordinary to H.M. the King.

It is a striking testimony to the advances made in our knowledge of the healing of wounds, that one of the most important points for present consideration in connection with the wounds of war is the geographical situation of the battle-field. In all old treatises on gunshot wounds we find that the authors devoted their attention mainly to the nature of the projectile and its direct effects on the tissues of the body; but, important as are still these considerations at the present day, they must now be studied in conjunction with the terrain of the war.

It is for this reason that I would preface what I have to say to you to-day with the statement that my own experiences are limited to two wars, the one in South Africa in 1899–1900, and the other the present war in Northern France and Belgium. And so widely different have I found the conditions of the wounds in these two campaigns, that I realize it would be unwise to speak too dogmatically of wounds in those many other fields of the war now being waged in different parts of the world. I propose therefore to speak to you only of those I have seen during the past fifteen months; for it was in September, 1914, that I went to France, at a time when the battle of the Aisne was in progress. From that time until the second week in October I was chiefly occupied at the hospitals at Rouen, although I also visited Paris and its neighbourhood.

Early in October, however, I was directed to join the General Head-Quarters in the North of France, and ever since that time I have visited daily the various casualty clearing stations at the front, and have also seen from time to time the work done in the field ambulances. My experiences, therefore, are on the whole concerned with recently wounded men; but many of these latter have been kept under observation for several weeks, either in the clearing station or in the large stationary hospital where Mr. W. S. Dickie is in chief surgical charge.

In the first place I wish to point out how radically different are the fields of war in South Africa and in France. In the former we had to fight in a very thinly inhabited country, which supported few domestic animals, and which for the most part was quite uncultivated. The soil was dry and sandy, and in many places the rocks projected in the form of the well-remembered kopjes. The ground was uncontaminated by manure, and was to a great extent virgin soil. Rainfall was slight, cloudy days were few, and a hot sun with fresh breezes or strong winds desiccated the soil and prevented the growth of any luxuriant vegetation. The consequence of all these conditions was that, in the absence of decaying vegetable and animal matter, the soil was almost

entirely free from all pyogenic organisms, and bacteriological examination proved that all forms of pathogenic bacteria were absent from the soil of the veldt except in the neighbourhood of the dwellings of man.

At the present seat of war we find all these conditions reversed. The country is thickly populated with human beings, and supports many cattle and pigs; the soil is a rich loam, and rocks nowhere project through it; it is more heavily manured with the excrements of men and animals than almost any other land, and is covered by luxuriant crops. Rainfall is copious, cloudy days are numerous, and in many months sunshine is almost absent for long periods. One result of these conditions is that every form of micro-organism flourishes, and even in soil taken from a considerable depth below the surface, the spore-bearing pathogenic organisms abound.

The behaviour of the wounds in the two wars presents an unfortunately grave difference which corresponds to some extent with the conditions I have just enumerated. But, in addition to the differences in the soil and surroundings, the wounds of the South African war also differed in almost every way from the injuries of the present campaign. The ogival bullet of that day produced much less smashing and rending than does the pointed bullet now in use; and while in this war the majority of the wounds are inflicted at close range by a missile travelling at the height of its velocity, in South Africa they were more often due to bullets fired at a distance of half a mile or more, which, travelling at a much lower speed, had infinitely less power for harm.

In addition to this, shell wounds amongst the British troops were extremely rare in the African campaign, while in this war they are perhaps quite as numerous as those caused by bullets. In general terms it may be said that the injuries seen in the Boer war were infinitely less severe, and the complications due to them far fewer and less serious, than those of the past year in France, so that it was very soon evident that we had to unlearn most of our South African experiences.

I will give but one example to illustrate this. In January, 1900, two Australian troopers were sent into the Portland Hospital in South Africa, in each of whom the femur was fractured and comminuted in its upper third by a bullet. The injuries were three days old, and the only treatment had been the application of a small first field-dressing, and the bandaging of the limb to a rifle with puttees thick with dust. The blood-stained breeches had not been removed, and the first dressing and the puttees had not been changed. Yet the men were in excellent condition, and their wounds never gave the slightest trouble.

But similar injuries with similar treatment in the present war would almost certainly have resulted in the death of the patients from gangrene, or at least in a prolonged suppuration and probable loss of the limb; and many surgeons who are familiar only with South African conditions seem unable to realize the completely altered picture of the present war.

I am very well aware of the difficulty of explaining with sufficient clearness the conditions under which our men in France are wounded and treated; nevertheless, before I attempt to describe the general nature and treatment of their wounds, I will endeavour to put before you the circumstances in which these wounds are received.

THE EVACUATION OF THE WOUNDED.

You are all well aware that ever since the battle of the Marne the opposing armies have lived and fought in trenches; but it must be remembered also that in both of the battles of Ypres, as well as at Neuve Chapelle and Loos, and on many other occasions, there has been a great deal of fighting in the open as well. Still, the fact remains that, owing to their partially subterranean life, men are usually covered thickly with either mud or dust at the time when they are wounded, and that their comrades who help them are in a similar condition. When a man in one of the advanced trenches is hit and falls, he lies in mud or dust, or else in muddy water a foot or more in depth. Close at hand, or else perhaps some hundred yards distant, the regimental medical officer has prepared a larger and deeper excavation commonly known as a dug-out, and to this the wounded man will walk if he is able. If unable to walk he must be carried; but he cannot be carried on the usual stretcher, because it is too long to pass along the narrow trench which is rendered tortuous by the many traverses. Under these circumstances he may be carried sitting on sacking slung from a pole (*Fig.* 145), if he is well enough to help himself, or else he may be taken on a 'trench stretcher' (*Figs.* 146, 147), which is much shorter than the usual stretcher, and is a very simple and ingenious invention which has been of great service. His wound is not infrequently dressed by his muddy and dusty comrades if it is accessible to them, and in any case it is dressed in the dug-out, if not before. From here the patient has now to be transferred to the first-aid post, which is established by a section of a field ambulance at some place which is as much sheltered from fire as may be, half a mile or more in the rear. Access to this is generally obtained by passing along a communication trench, which may be six or eight feet deep, and more or less muddy or wet. The first-aid post is usually above ground, but may be in a dug-out or in a cellar. The patient is not detained here longer than absolutely necessary, but is transferred by a horse-drawn vehicle or on a wheeled stretcher to the main field ambulance a mile or two further back. Here are either tents or buildings which have been adapted for use, and here fresh dressings and food, and much needed rest on stretchers, are all provided. The wounded man is

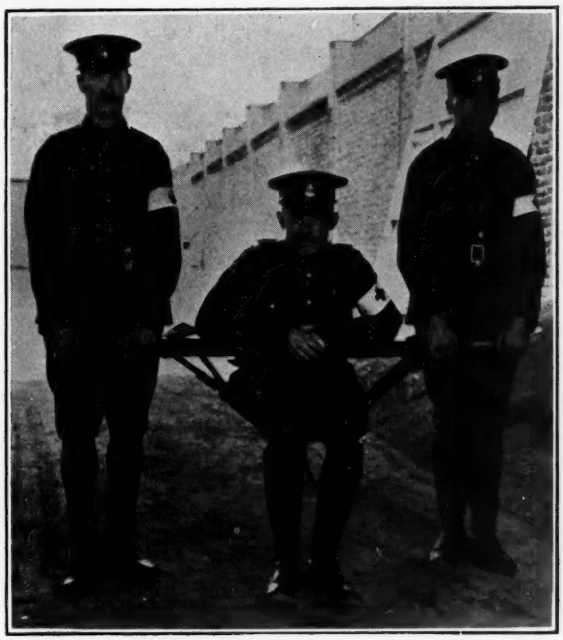

FIG. 145.—SEAT MADE FROM SACKING AND A POLE.

now in comparative safety, and if his injury is slight and there is no crowd of wounded, he may remain here for some hours. If, however, his wound is serious or dangerous, or if a battle is in progress, he is taken in a motor ambulance to the casualty clearing station a very few miles further back, and usually placed so as to be just out of the range of ordinary shell fire.

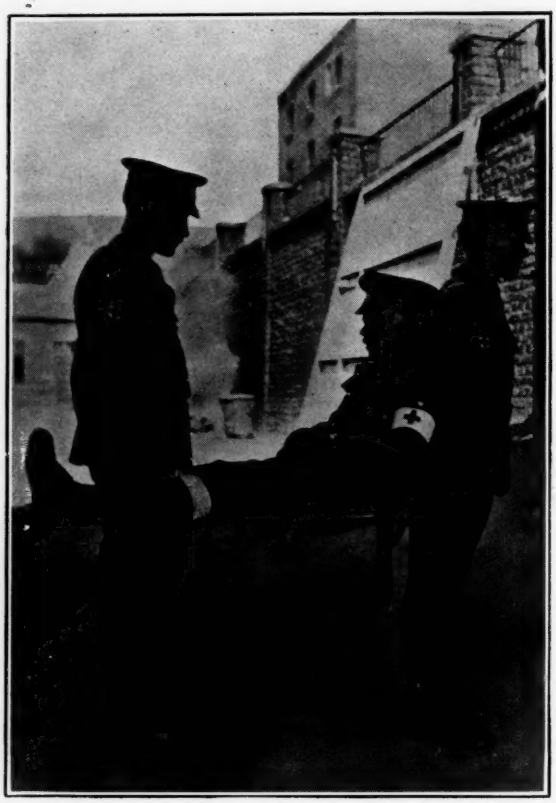

FIG. 146.—"TRENCH STRETCHER" COMPLETE.

These clearing stations were invented at a date subsequent to the Boer war, and were for the first time put to a practical trial in the present war. Their personnel and equipment were provided for the treatment of two hundred wounded, and they were originally intended merely to enable the field ambulances to 'clear' themselves, and then to pass the wounded on to the stationary hospitals or to the base. The circumstances of this war, however, soon showed that they could be made infinitely more useful than this, and before the end of the year 1914 they had been transformed into well-equipped hospitals capable of dealing with all urgent operations, and of retaining and nursing those patients whom it was not advisable to send on by rail. It is into such hospitals as these that the wounded come from the field ambulances, and at which they often arrive within a very few hours of being injured.

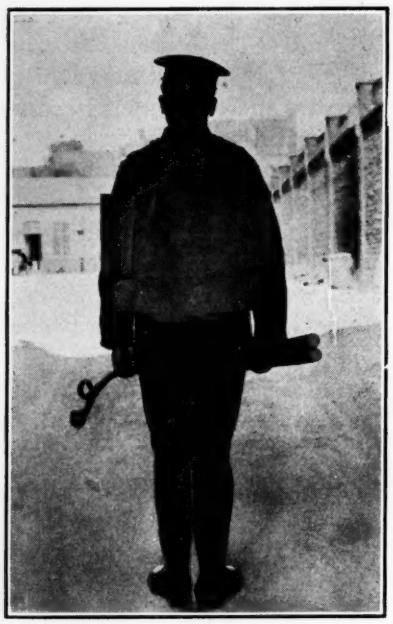

FIG. 147.—"TRENCH STRETCHER" DISCONNECTED FOR TRANSPORT.

It must next be realized that in the early days of trench warfare the long communication trenches of the present day did not exist, for they may take months to complete; as a consequence, men had usually to be retained

in the advanced or support trenches till night afforded some protection from the enemies' fire, and in this way much delay necessarily ensued in getting the patient out of his muddy surroundings, and to a place where he could be adequately treated. There are some trenches in which similar conditions still prevail, and from which the wounded can only be evacuated after dark.

On many other occasions, after a fight in the open, badly-wounded men have been left lying between the opposing trenches, because any attempt to rescue them at once drew the fire of the enemy, and might easily have resulted in the death of the patient as well as of his would-be rescuers. In such circumstances, after nightfall, men will crawl in even with badly-smashed limbs, and in other cases they are brought in by stretcher-bearers at very great risk. Others of them, however, cannot be brought in, and, especially after an unsuccessful attempt to capture an enemy position, they sometimes lie out for even days and nights. No doubt many such have died, and in others who have been ultimately rescued, the condition of the wounds has been very bad. It was, of course, the men who were the worst wounded who had the most difficulty in getting into our lines, for those who had badly fractured legs or thighs, or were shot through the head, the lungs, or the abdomen, were quite unable to save themselves, and had to wait till the enemy was driven back, or till darkness allowed their comrades to try and help them, in spite of the light given by the frequent star shells and the subsequent fire from the German lines.

One man lay out in a coppice last January for ten days, with only a little pond water to drink, and lost both his feet from gangrene, but escaped with his life. Another man lay for eight days in a German dug-out with a completely smashed leg, and in constant expectation of being discovered and killed, yet he also survived after amputation of the leg.

THE NATURE OF THE MISSILES.

It is now time to turn attention to the nature of the missiles which cause the wounds we are considering; and they are certainly more varied and numerous than in any previous war. It is not yet possible to say with any accuracy what proportion *rifle bullet* wounds bear to the whole; and it must be remembered that the quick-firing machine gun which has borne so prominent a part in the German armament, fires the ordinary rifle bullet, as does also our own quick-firer. The British, German, and French rifle bullets, alike differ from all the bullets of the Boer war period. The point of the older bullet was rounded or ogival, and the whole bullet was of the same diameter in nearly its whole length. The point of the present one is like that of a sharpened lead pencil, and the consequence is that the balance of the bullet is altered, so that its posterior half or base is much the heavier, and its centre of gravity further back. The importance of this to the patient and the surgeon is that the bullet is very easily turned completely over on its short axis, and so enters the body sideways, or base first. This is all the more likely to occur, because in trench warfare bullets often pass through the earth of the parapet, or strike a sandbag; but it is also true that when the speed of one of these pointed bullets is much diminished towards the end of its flight, it will readily turn over within the body after entering with its point first.

The German and British bullets are much alike. Each of them consists of a soft core of lead or other metal contained in a sheath or 'mantle' of hardened steel, and, though the German bullet has a higher muzzle velocity, I do not think there is much difference in the effects it produces in the human body, and I have seen a considerable number of Germans who have been wounded by our bullets. As is well known, the impact of the mantle-coated bullet on a rock or stone may break the mantle and allow the core to extrude, so that when it strikes a resisting structure, such as a large bone, it spreads and breaks up and causes much more extensive damage to the tissues as a result. In my experience it is seldom that the bullet is broken up by mere impact on a bone, though no doubt this does occur.

The French bullet is made of a copper compound, and is solid and homogeneous throughout, so that it has neither core nor mantle; it is longer and heavier than either of the other bullets. As I have not seen very many patients wounded by it, I do not propose to allude to it further, beyond saying that I think there is very little difference in the effects it produces on the human body.

In addition to bullets, an immense number of other forms of missile have been employed, so that wounds have presented the utmost variety. It is not possible or necessary to describe in detail all the forms of shell; but in order to understand the nature of wounds it must be realized that shells differ immensely in their structure and in the way in which they produce injury.

1. *Shrapnel shells* of all kinds and sizes are characterized by the fact that they contain some 250 to 400 round bullets of lead, which in some shells is soft, but in others is hardened by various agents. These bullets vary in size—in proportion to the size of the shell—but are never more than about half an inch in diameter. The shell is usually timed by a fuse to burst in the air over the object aimed at, and the shell case being blown open by the explosion, the bullets are propelled in a cone-shaped stream whose velocity is dependent on the velocity of the shell, and is not due to the force of the explosion which bursts the shell. The violence of their impact is great in proportion as the shell is still travelling at high speed and is not too far from the ground when it bursts, and the direction of the blow is generally downwards. Wounds may also be caused by the metal case, which is a foot or more long and weighs several pounds at least; but such wounds do not differ from those caused by the solid variety of shell. The velocity of the bullets is never as great as the muzzle velocity of a rifle bullet, and as they very quickly lose force and power of penetration, their effective range is not a long one.

2. *High-explosive shells* vary in weight from a few pounds to about a ton, and they consist of a thick iron case containing in a central cavity a violent explosive charge. The latter is, in the case of German shells, trinitrotoluene, and as much as 200 lb. weight of the explosive may be present. Such shells are usually burst on percussion by a detonator which acts by the impact of the shell on the ground or on some other object. These shells do not contain bullets, and the injury they do is caused in chief part by the jagged fragments into which they are split by the explosion, and also to some extent by the impact of portions of buildings, such as stones or bricks, which are scattered with immense force by the violence of the explosion. The fragments of the

shell are always very rough and ragged, and of every variety of size and shape. For example, the base of a 17-in. shell may weigh 150 lb., and if it struck the body of a man would completely destroy it: other fragments may weigh a few pounds, and may tear off a limb or crush it to pulp; while in the smaller shells, there may be scores of fragments about the size of the end of a finger, or much smaller.

It must also be kept in mind that the mere explosive force of the gases of a large shell exercises great powers of destruction. The expansion of the gases is alone sufficient to kill, and in the only case in my experience in which an autopsy has been made, the brain was the seat of very numerous petechial hæmorrhages.

3. *Bombs from trench mortars, hand grenades, rifle grenades, etc.*, all consist of a shell-case of iron or other metal, containing a relatively large charge of a high explosive. In the German projectiles this is always trinitrotoluene. The bomb case varies immensely. In some it is composed of iron about half an inch thick, which is often partially cut up into segments about half an inch square. In others, chiefly German, it consists of quite thin steel. When a bomb or grenade bursts, the case is commonly broken up into very numerous fragments of every size, from a pin's head to a lump of metal weighing several ounces. Some of these may be quite pointed, and with an edge like a knife; others are often quadrilateral. Some of the German bombs contain also irregular jagged pieces of loose metal, and others are loaded with rough iron boot-nails about half an inch long and pyramidal in shape.

All forms of shell and bomb also scatter stones, earth, or sand from the parapets, and these all become projectiles, and are specially liable to injure the face, neck and shoulders of men standing in the trenches.

CHARACTER OF THE WOUNDS.

Such, then, are the various projectiles by which the wounds of the present war are caused, and it will be readily appreciated that the wounds are as various as the projectiles themselves.

The so-called 'normal' bullet wound, such as was common in the South African war, and was characterized by a tiny aperture which might have been made by a gimlet or a trocar, is in this war quite rare, and even if the entry is of this nature, the exit is almost always ragged and large. In many of the cases bullets tear the soft tissues to rags, and blow out the muscles and fascia through great rents in the skin. When no bone is struck, such injuries as these are always due to the discharge of the rifle at close quarters, and generally within fifty yards. When a large bone is struck, the damage is yet greater, and the part looks as if it must have been struck by a large fragment of shell. This is due to the fact that the bullet, travelling at the height of its velocity, not only smashes the bone, but also imparts its momentum to the shattered fragments and drives them in every direction, so that the injury to the soft tissues is inflicted in great part by the fragments of bone themselves.

Wounds caused by shrapnel bullets are not as extensive as the worst of those caused by the pointed rifle bullet; for although the former may make large holes of entry, they do not exercise the same divulsive or explosive force

as the latter; they are, however, often multiple, and on account of the fact that this form of shell bursts in the air, the bullets very often wound the skull and brain.

The wounds caused by high-explosive shell-fragments, and by bombs and grenades, are so infinitely various that it is not possible to describe a characteristic shell wound as a type. It may be noted, however, that, all shell fragments being rough and jagged, they tear away parts of the clothing and carry the latter into the extreme depths of the wound. The large fragments tear away portions of skin and muscle from the limbs or trunk, so that the whole of the calf, or the front of the thigh, or the gluteal or deltoid region, may be destroyed, and the tissues from which these have been avulsed are so crushed and lacerated, that all the vessels are pulped, and extensive areas die. In the neighbouring tissues there is of course widespread contusion or extravasation of blood, and, as a result of these injuries, the exposed muscle often loses all its natural characteristic appearance, and looks exactly like a mass of mud, for it becomes a homogeneous mass of dark brown or slate-coloured matter without any appearance of striation or vitality; and, as it is quite dead, it may be cut away without causing either bleeding or pain. The condition is one which I have never seen in even the worst machinery accidents in civil life. In other cases, fragments of big shells may tear away the abdominal wall and expose the viscera, or may carry away portions of the face or neck, while the bones of the limbs may be fractured, or the limb itself may be completely shot away.

Nothing is more striking than the immense amount of destruction wrought by even quite small pieces of a shell burst by a large charge of a high explosive, for the wound in the tissues may be ten times as large as the missile. Thus, I have seen a man in whom a piece of shell not so big as the end of the little finger tore a large wound in the liver and then rent completely away the whole of the hepatic flexure of the colon; while in the limbs I have seen wounds as large as a clenched fist caused by quite small fragments, which evidently owed their power of destruction mainly to the extraordinary velocity with which they travelled, as well as to their jagged edges.

The various forms of bombs and grenades are specially liable to cause multiple wounds, for they generally burst close to the patient; they break up into very numerous fragments, some of which are large and heavy, while some are quite minute. At very close quarters, quite small, sharp-edged strips of metal may penetrate very deeply, and even be driven into the intestine or lungs through tiny apertures; while many other men who are hit at some little distance by similarly small pieces of these bombs, suffer little violence, for, as the fragments quickly lose their great initial velocity, such wounds as these are often slight. It has thus happened during the last months of the war that a very large number of men have had small wounds from which they quickly recovered; although, on the other hand, it is often noticeable that many of these grenade and bomb wounds are on the face, and that one or both eyes are often blinded by small pointed fragments, or by gravel or mud. These wounds are also specially liable to be infected, and for the reason that, as the bomb usually falls to the ground before bursting, it scatters showers of mud in every direction and plasters it into the wounds.

It will thus be seen that the wounds in this war are often quite unlike those of previous wars, because they have been caused by new and different missiles; and it is further to be noted that the proportion of wounds by rifle bullets compared to wounds caused by shells or bombs is certainly much less than in previous wars. It is well known that never before has such extensive use been made of artillery and bombs, nor have armies ever previously faced each other over fronts of hundreds of miles at a distance of a few yards. It is this proximity and shortness of range which has caused bullet wounds to be so severe, and it is by the same proximity that the injuries by bombs have been made possible and frequent.

The very various wounds I have thus briefly described are, for the most part, quite different from injuries met with in civil life, and all surgeons in past years who have had war experience have recognized that gunshot injuries form a class alone. It is of course true that a very large number of slight and superficial wounds, and some cases of fracture, present no striking features; but where missiles have penetrated the body at high velocity, the differences between such injuries and those of civilian life are radical.

Special Characteristics of Gunshot Wounds.—The essential nature of all accidents such as are caused by machinery in motion, by vehicles of all kinds, or by kicks or blows, is a crushing and mangling of the limbs or trunk by force applied from without inwards, so that the parts involved are crushed by a comparatively slowly moving object. On the other hand, in all penetrating wounds by bullets of all kinds and by shell fragments moving at immense speed, the main injury is done by a force of a divulsive or expanding nature, so that the tissues are torn asunder from within instead of being crushed slowly from without. It is this rending asunder which is the special characteristic of all typical 'gunshot' wounds, and it has been shown that the injury caused by a bullet is largely due to the wave of compressed air which the bullet drives in front of it, and which expands within the tissues. In all wounds which completely traverse the tissues, this divulsive or explosive force is present to a greater or lesser extent, and the effect produced is heightened by the resistance offered to the explosive power. The result is that the injury, instead of being limited to the tissues on each side of the bullet track—as it would be if the wound were not made by a bullet but by a trocar—is diffused in every direction, and radiates through all the surrounding structures. It is, of course, well known that in the case of the brain enclosed in the skull, or the liver enclosed in its capsule, explosive effects are typical, and this is attributed to the enclosure in a strong capsule of tissues which are largely composed of water. But it is not sufficiently appreciated that these same effects are produced in every other part of the body and limbs also, and are directly proportionate both to the speed of the whirling projectile and to the resistance offered it by the structures which it encounters. The truth of this may be demonstrated on any limb shattered by a bullet or a fragment of a high-velocity shell perforating it; for it will be found on examination that the missile has not only shattered the tissues in the line of its flight, but that the divulsive force has separated the fascia from the skin, and split the muscles from each other along their intermuscular planes. The effect of the injury may, indeed, spread up and down

a great part of the length of the limb, and vessels may be burst and extravasation of blood may be found, far from the obvious track of the missile.

Microscopical Examination of Injured Tissues.—But, although the effects of a bullet or piece of high-velocity shell are so evident and extensive, it will be found by microscopical examination that they are even more extensive than appears to the naked eye; for if muscles whose sheath is yet intact, which appear perfectly normal, and which are at some distance from the wound, are so examined, there will be found fractures of the muscle bundles, extravasation of blood, and necrotic changes in the surrounding fibres.

FIG 148.—*Case* 1. MICROSCOPIC SECTION THROUGH UNWOUNDED POLE OF KIDNEY.
The tubules show desquamation of their epithelium, and many of them contain red blood-corpuscles, which are also scattered throughout the section. This part of the kidney appeared healthy to the naked eye.

This microscopical evidence of wide-spread injury is found not only in the limbs but also in the viscera, so that the liver and the kidney may show extensive interstitial hæmorrhage, and a very remarkable disintegration of the cells, at a considerable distance from the site of the obvious injury. I am much indebted to Lieuts. Adrian Stokes and McNee for the following reports on various specimens they have examined—on which, amongst others, the above statements are based.

***Case* 1.—Shrapnel Wounds of the Chest and Abdomen.**

Sergeant C. died about twelve hours after being wounded, and the right kidney presented a perforation in its lower pole. A piece of kidney was taken from what was apparently a healthy portion of the upper pole, for microscopical examination. It was hardly recognizable as kidney. There was present only a fibrous stroma of

the tissue without any of the specific kidney cells, and only one or two glomeruli were recognizable (Fig. 148). The tubules had apparently desquamated all their lining epithelium, and in a few of the collecting tubules there was present some granular material, perhaps representing the destroyed cells. The whole section was full of small hæmorrhages, and in places there was a slight infiltration with polymorphs.

Case 2.—**Wound by Bullet of Anterior Margin of Liver.**

Private, No. 2 C.C.S. Wounded 2.30 p.m., October 6, 1915; died 8.20 p.m., October 7, 1915.

CONDITION OF LIVER.—The bullet had penetrated the organ close to the anterior margin, just internal to the line of the gall-bladder. The laceration extended for a depth of 1½ inches into the liver substance. On cutting the liver into two parts, so

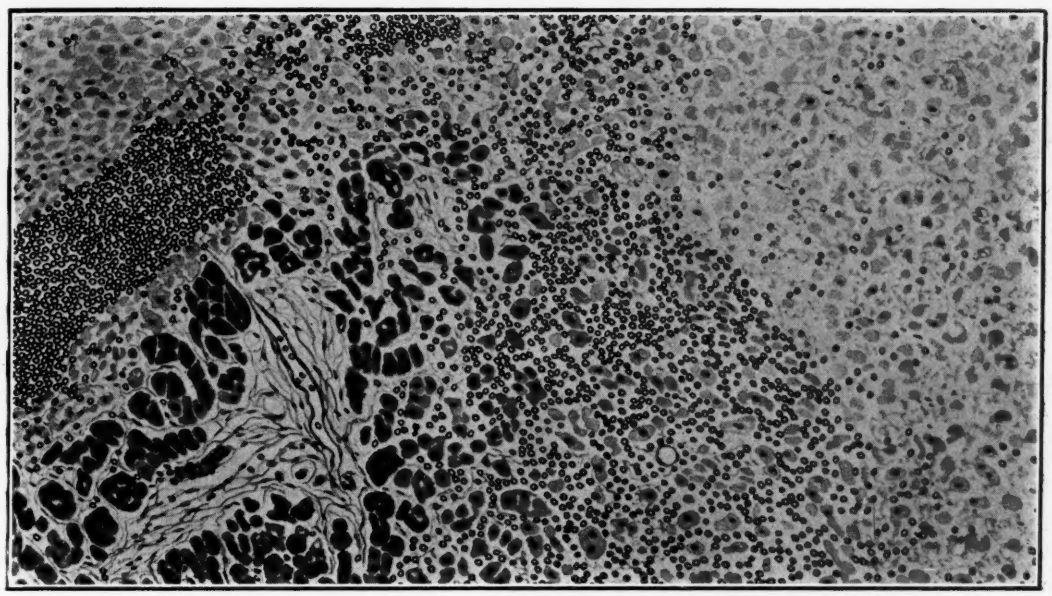

FIG. 149.—*Case* 2. MICROSCOPIC SECTION OF LIVER THREE INCHES FROM THE WOUND.
The figure shows a large hæmorrhage, with necrotic liver-cells outside it.

as to include the line of the laceration, an irregular area was observed, different in colour from the other parts of the organ, and situated almost three inches from the tear. No direct track could be found leading from the site of the injury up to this yellowish area.

Microscopic sections (*Fig.* 149) from this yellowish zone showed the following appearances: "The cells of the lobules are in many places very well preserved, the only abnormal feature being the great vascular engorgement of all the capillaries. Scattered throughout the sections, however, are numerous hæmorrhages, some of them exceeding in size two liver lobules. Round the margins of the areas of hæmorrhage the liver cells are definitely necrotic, nuclear staining being lost, and the protoplasm granular and faintly staining. In most places the ring of necrosis is narrow; but in others a wider area is involved in the process. In some sections areas of necrosis alone seem present, but these are evidently in relation to hæmorrhages not included in the same section. No leucocytic infiltration or other evidence of sepsis is present anywhere."

Case 3.—**Wounded by Shell 9 a.m. Oct. 11, 1915.**

Corporal, Sherwood Foresters. Superficial injuries to foot, hand, and scalp. Three deep wounds on front of right upper arm, just below insertion of pectoral muscles. Patient collapsed from hæmorrhage on admission. Amputation was performed at the shoulder-joint on October 13, and tissue was taken for examination from the belly of the biceps muscle, two inches below the lower margin of the wound, at a place where the muscle appeared to be quite normal.

CONDITION OF MUSCLE EXAMINED.—" The most interesting finding is the presence of a definite transverse rent, tearing across several bundles of muscle fibres, as seen in longitudinal section (*Fig.* 150). The ends of the muscle fibres torn across show necrosis, and the rent itself is filled up entirely by a mass of red cells and polymorphs, showing an intense inflammation to be present. Everything points to this small tear having occurred at the time of the original injury higher up the arm.

FIG. 150.—*Case* 3. MICROSCOPIC SECTION OF MUSCLE TWO INCHES BELOW THE WOUND.

A rent, filled with blood, runs transversely across the fibres. The naked-eye appearance was healthy.

In other parts of the sections bundles of muscle fibres are widely separated, the interval between the bundles being filled entirely with polymorphs and red cells. One such bundle, separated from its neighbours on either side by a gap containing inflammatory cells, shows absence of all striation of the fibres, and is evidently approaching a condition of necrosis."

Case 4.—**Gunshot Wound of left Leg above Ankle, causing Compound Fracture of both Bones.**

Private F., 6th D.C.L.I. Wounded October 11, 1915. Amputation twenty-four hours after the wound was received.

Muscle tissue taken for examination from the tibialis anticus, several inches above the seat of the wound.

CONDITION OF MUSCLE EXAMINED.—" The most striking feature in the sections is the wide separation of bundles of muscle cells from one another. A condition of very acute inflammation is present, all the spaces between the bundles being full

of polymorphs. A distinct transverse tear is seen going half-way across one bundle. The muscle fibres involved in the tear are quite without striation, and obviously necrotic. The gap between the torn ends (see *Fig.* 150) is filled in by polymorphs and red corpuscles, indicating, along with the necrosis of the muscle fibres, that the rupture occurred ante mortem, and not during the preparation of the sections."

Other Far-reaching Effects.—It is very easy to demonstrate the far-reaching effect of bullets when the bones are involved, and I will quote the two following cases as striking examples.

In the first case a man was shot across the face and through the nasal cavities, the entrance wound being below the zygoma on one side, and the exit through the zygoma on the other side. His symptoms were those of a man shot through the brain, and he died on the fourth day. The autopsy by Mr. Adrian Stokes showed that, although the track of the bullet was an inch or more below the level of the base of the skull, yet the latter was fractured right across, and, although the dura mater was unhurt, one frontal lobe and one temporosphenoidal lobe were more or less pulped.

In the second case a young officer was shot across the back of the neck and became completely hemiplegic, although the wound was apparently superficial. He died in two days, and an autopsy by Mr. Stokes showed that the bullet had only broken off the tip of the 6th cervical spine. The laminæ were not fractured and the dura mater was intact, yet the cord had been contused, and its grey matter was broken up by hæmorrhage. But it is possible also for the spinal cord to be injured by a bullet which does not even touch the vertebral column, and one patient died with hæmorrhage into the spinal cord in whom the bullet had merely passed through the muscles at the side of the neck and had caused no hurt to any of the vertebræ.

Other very striking examples may be cited where the intestines have been torn open by bullets without the peritoneal cavity being opened. In one case a bullet passed across the pelvis at the level of the trochanters, causing immediate collapse from which the patient never rallied. He died in about ten hours, and at the autopsy it was found that the bullet had passed in front of the sacrum, and had not entered the peritoneum. Yet when the peritoneum was opened anteriorly, it was found that a coil of the ileum six inches from the cæcum had been completely torn across.

In a second case of the same kind, a bullet entered the upper gluteal region and emerged in the inguinal region, cutting the spermatic cord but not opening the peritoneum. Nevertheless the patient died from rupture of the intestine.

It will thus be seen that, whatever tissue is examined, or whatever part of the body is involved, all the evidence goes to show that in gunshot wounds the passage of the missile results in injuries to tissues which appear to be quite remote from its track; and it must be concluded that the vibrations set up by the projectile in the fluids of the body result in very wide-spread disintegration both of the small blood-vessels and of the cells of the parenchyma themselves.

As will be seen on further consideration, these changes are of great interest in considering the resistance of the body to microbic infection.

Condition of the Wounded.—The next matter which demands consideration is the condition of the wounded men themselves. This necessarily depends

on other circumstances besides the nature and extent of the wound, for it is influenced by the time that elapses before assistance arrives, by the amount of blood lost, by exposure to cold and wet, by want of food and drink, and by exhaustion due to want of sleep; and it is seldom that even in the case of slight wounds none of these factors complicate the injury.

I think that what would strike most forcibly any observant person who was brought into a room filled by large numbers of recently wounded men from an important fight, would be the fact that nearly all of them were asleep, in spite of wounds which one might well suppose would effectually banish sleep. There they lie on their stretchers, with muddy or wet clothes, with bandaged limbs or head, quite content with the transition from the turmoil of battle to the comparative peace of a crowded room which in itself offers little comfort. Some of them ask for food; but with many this is a secondary consideration, for when a man is worn out by long periods of watchfulness and laborious work in the trenches, and when the intense excitement of fighting for life and killing other men in the midst of the crash of shells and the clatter of rifles and machine guns has passed, then there comes the reaction and exhaustion of a tired-out man and an overwrought nervous system. It is only a few of these men who are excited and talkative, and still fewer who wish to talk of their recent experiences; and those who only see wounded men in the base hospitals have little idea of the silence of a crowded room in a clearing station when heavy fighting has been in progress for a day or more.

But as the surgeons work their way from man to man, it soon becomes evident that some of those who are asleep are also suffering from profound collapse, so that there are many in whom the hands and feet are cold, the lips pallid, and the pulse is either very small and rapid or quite imperceptible at the wrist. The wound of such a patient may for its own sake demand prompt treatment, but all who have had experience know that there are hundreds of men whose best chance of life is to be kept warm and left absolutely quiet, and persuaded to take hot soup, or cocoa, or perhaps alcohol, before again going to sleep. It is at first surprising to find how many quite pulseless men will slowly pull round if they are only given time and kept thoroughly warm; and there are no more striking cases of this than men with bad compound fractures of the lower extremities, or with multiple injuries. They are indeed often so nearly dead that it may be several hours before any attempt can be made to dress their wounds, and even with every care there are not a few who die. The common causes of this collapse I have enumerated above; but it is often true that various causes all combine to bring about the condition. It thus happens that when a man has had a bad smash of a limb by a bullet or shell, the shock caused by such an injury is alone sufficient to cause much collapse. Yet in many cases this is followed by the anxiety of prolonged exposure to further wounds, and often by hours of wet and cold spent in the open, with no food, and with an undressed wound which hourly becomes more painful. And after all this, there is the unavoidable pain of being moved from the battle-field to the hospital.

It is also a very noticeable fact that in many of these cases the patients are quite unable at first to retain any food, and that, even if no food is taken, retching and vomiting are very common for many hours. This is a complica-

tion of shock of which I have had no similar experience in civil practice; but it is unfortunately not only common, but often serious, in gunshot wounds, as men who are much in need of food are unable to retain it. In many of these cases of vomiting, and also in all cases of severe collapse, numerous lives have been saved by the subcutaneous or intravenous injection of normal saline solution to the extent of several pints, and enemas of hot water and brandy have been similarly useful. As far as drugs are concerned, nothing has been more helpful than pituitary extract. There are also many men who have sustained multiple injuries from bombs or shells, and some of whom have had two or even three compound fractures, and no class of case suffers more from shock than this. In others of these cases of multiple injuries, the whole chest or back, or the surface of both thighs or legs, is covered with numerous wounds which are caused either by fragments of the bomb or else by gravel and stones from the parapets, and although the wounds may be quite superficial, the patients are very frequently severely collapsed. I have been in the habit of comparing these cases of multiple surface wounds with those of extensive superficial burns, where there is also much shock, and I think the two classes have much in common; for not only do they suffer from shock, but the sepsis following a burn is more than paralleled by the severe infection with anaerobes due to the multiple infection carried in by the mud and bomb fragments. As, too, in the case of burns, picric acid is at once an excellent analgesic and antiseptic.

SECONDARY COMPLICATIONS OF WOUNDS.

The primary complications of hæmorrhage and collapse are accompanied or followed by the secondary complications of bacterial infection, and it is practically true that every gunshot wound of this war in France and Belgium is more or less infected at the moment of its infliction. I have already described the condition of the men and their clothing, and how mud and dirt pervade everything; and bacteriological investigations of the soil, of the clothing, and of the skin demonstrate the presence of the most dangerous pathogenic organisms in all three.

No more interesting work on this matter has been recorded than that done by Mr. Alexander Fleming* in Col. Sir Almroth Wright's laboratory, and his whole paper is well worth study. Here I will only quote some of his conclusions, and, in the first place, the results of his examination of the clothing of wounded men. He says, "From this it will be seen that of the 12 samples of clothing examined, *B. aerogenes capsulatus* was found in 10, *B. tetani* in 4, streptococcus in 5, and staphylococcus in 2, besides other organisms." It is therefore evident that the patient and all his surroundings when he is wounded are grossly infected, and all missiles which pass through the contaminated skin, as well as through the clothing, are liable to carry bacteria into the depths of the wound. And it must also be kept in mind, that, even when no large piece of clothing is found in the wound, in practically all cases of injuries by shells or shrapnel bullets, minute shreds of coat, shirt, or jersey will be found by a careful search.

**Lancet*, 1915, Sept. 18, p. 638.

Mr. Fleming gives the following table showing the microbic infection of 127 patients at different stages :—

Time after Infection	Total number of cases	*B. aerogenes capsulatus*	*B. tetani*	Putrefactive Bacilli		Streptococci	Coliform bacilli	Staphylococci	Wisp bacilli	Diphtheroid bacilli	Large bacilli
				B. x	*B. y*						
Stage I. 1 to 7 days	127	103	22	14	5	102	37	40	9	0	2
Stage II. 8 to 20 days	56	19	5	4	1	51	18	16	17	4	4
Stage III. Over 20 days	27	5	0	0	0	24	19	19	16	0	6

He adds: "The spore-bearing anaerobes . . . progressively diminish in relative frequency as the age of the wound increases. . . . In the early stages these spore-bearers are present in much greater numbers than anything else, whereas, later, . . . their numbers are relatively few." He considers also that all but the last two of the group of organisms tabulated above are of fæcal origin, including the streptococcus, which is so common an infection.

The work of pathologists at the front, Major Rowland, Lieuts. Stokes and McNee, has also demonstrated the presence of anaerobic and other organisms in quite recent wounds; and the conclusions arrived at in the British army are all supported by the surgeons in the armies of our allies.

Such then are the main facts as to the nature of the infection of the wounded parts; it is the result of this infection that is the all-important question which has so deeply interested, not only the medical profession, but also the public in general.

I think it may truly be said that nothing has more impressed the public mind than the septic nature of many wounds, and the prolonged sufferings caused thereby. It may also be said that this sepsis came as a surprise to most surgeons, and as a disappointment to those who had believed that in antiseptic surgery we had forged a weapon to combat all such conditions. Many indeed have not hesitated to blame the surgeons in France for the conditions of the wounds, while others have devised and advocated many new remedies to deal with the unexpected state of affairs.

It becomes, therefore, a matter of much interest to try to analyze the different bearings of this septic infection, and to suggest how it may best be combated.

In the first place we must realize that, as regards the gas-forming anaerobes at least, we have to deal with an infective process which is to all intents a new experience; and not only are these bacteria found in almost every wound, but they also attack the tissues more rapidly and violently than any other organism. They are practically unknown in civil practice in Great Britain as a regular wound infection, for they are so rarely encountered, that prior to this war most of the younger British surgeons had never seen a case of gas gangrene. I will not here interpose a long description of this condition, but

will merely state that these anaerobes cause an inflammation characterized by great swelling and a copious sanious discharge full of bubbles of gas. This may only result in a cellulitis, or may involve all the tissues of a limb, and has a special tendency to extend in muscles. It may cause discoloration and death of the skin alone, or else the whole limb may swell enormously and be rapidly converted into a gangrenous mass of putrefying material emitting the odour of a newly-manured field. The patient in the worst cases presents all the appearances associated with severe shock or collapse, is often very sick, rapidly becomes pulseless, his hands and feet become damp and cold, the tongue is dry and furred, and death follows the onset of the disease within about forty-eight hours. There is often very severe pain in the early stages, and most of this is due to the extreme swelling and tension ; but as the tissues die, all sensation is lost, and the end is usually quite painless. In the vast majority of wounds, however, although the same anaerobes are present, they are comparatively powerless to do much harm, their action is localized to the wounded area, and they produce merely a local sepsis and inflammation. The question naturally arises why such very various results should ensue from the same infection; and it is a noteworthy pathological fact that the action of the gas-producing organisms is greatly assisted by the presence of staphylococci or other bacteria.

In considering the explanation of these phenomena, we are at once struck by the fact that these anaerobes attack a recent wound with the most alarming rapidity, and they produce their characteristic local and constitutional effects more rapidly after being inoculated than do any other organisms. I have indeed seen well-marked infection, with the formation of gas, within five hours of the receipt of a wound ; and I have seen a whole limb gangrenous, and the patient dead from hæmic infection, sixteen hours from the time he was injured. It is evident, therefore, that in such cases the organisms meet with no resistance from the tissues ; and the question to decide is, why the tissues do not resist in some cases, when in very many other wounds the anaerobes have evidently but little power for harm.

A good deal of light is thrown upon this matter by the behaviour of the anaerobes in question when a limb dies from injury to its main vessels. I have seen many cases of gangrene due to injury to the iliac, femoral, or popliteal vessels, and some of injury to the axillary artery ; and in every case but one, immediately the limb has died from loss of its circulation, it has at once been invaded by the gas-forming anaerobes, and if it has not been removed, typical gas gangrene has extended, and killed the patient. In other patients, where wounds have been infected to only a slight degree before death, as soon as death has occurred typical gas gangrene has so rapidly spread, that within three or four hours the limb has become a putrefying mass.

The important facts to keep in mind then are : first, the extreme rapidity with which recent wounds become infected ; and secondly, the fact that these anaerobes develop most characteristically on dead or dying tissues. And, keeping these in mind, we can then appreciate why certain wounds are affected more than others ; for, other things being equal, it may be briefly said that " The more severe and extensive the injury, and the more the tissues are lacerated and devitalized, the more is the wound likely to be badly infected."

I have already described how the tissues are pulped by bad shell-smashes, and by bullet wounds with explosive effects, and I have mentioned that the muscles which have been crushed out of all resemblance to muscle may be cut away without causing pain or bleeding, because they are dead. The fact is that the tissues left behind, when a piece of shell has torn away a great mass of skin, cellular tissue, and muscle, are either dead or partly devitalized over a very large area, and I have described how microscopical examination shows that the injury is really very much more extensive than it even appears to be. It is in the widely extravasated blood, and in these dead and dying tissues, that the anaerobic bacilli in particular find an unresisting prey; and it is a matter of daily experience, that in the very large shell wounds of the shoulders and pelvic region, where amputation cannot be performed, gangrene almost inevitably supervenes. In simple flesh wounds it is quite rare, and the peritoneum is practically immune even when the abdominal wall is fatally infected.

Much of what I have said of the anaerobic bacilli is true also of the streptococcus which is found in such large numbers by Mr. Fleming; for Sir Almroth Wright has specially pointed out that this organism, like the anaerobic bacilli, also grows with extreme rapidity. It is therefore evident that in the wounds in France there are at least two organisms with which in civil practice in England we are not familiar. The whole group of fæcal bacilli has been hitherto comparatively unknown in modern surgery. It must of course be evident that the common pyogenic streptococci and staphylococci are also liable to infect wounds in France as well as in England.

THE CONDITIONS OF THE WOUNDED THAT FAVOUR SEPTIC INFECTION.

But, important as are the nature of the wounds and of the microbic infection, if we are to realize to the full the conditions that favour the growth of organisms, we must turn from the conditions of the wounds to the conditions of the patients; for the wounds that undoubtedly do the worst, apart from the severity of the injury, are those in which the patient could not be rescued for some time and has been left lying out and got thoroughly chilled, or has had severe bleeding: these two conditions are often combined.

As I see it, the whole picture is much as follows: The man is wounded, and simultaneously inoculated with organisms which immediately fasten upon any dead tissue. The safety of the patient depends for the time on his own inherent ability to resist; and if he is collapsed from loss of much blood, and is wet, cold and starving, his leucocyte defence is enfeebled or absent; the bacteria grow unopposed, and either destroy only the unresisting dead or partially devitalized tissues locally, or else, in addition, poison him by their toxins. The condition of the man himself to a great extent determines the reaction of the injured part, and must be taken into consideration, together with all the local complications, if the infections of wounds are to be really understood.

It is very natural, therefore, that suggestions should have been made for the application of an antiseptic agent by the wounded man himself or his comrades as soon as he is wounded. But although such treatment sounds plausible, it is really perfectly useless; for not only would very large quantities

of any agent be required for the numerous large wounds, but it would be obviously useless to employ antiseptics unless they could penetrate to all injured tissues, and unless the wound could at once be protected from further contamination. If the man lies in the open, he generally cannot get at his own wound at all, either because of its situation, or because he cannot remove his clothes, while he is also tolerably certain to be shot if his movements show that he is yet alive. Or, if one pictures to oneself the wounded man lying in a deep and narrow trench, still covered by his muddy clothes, possibly in the dark, and perhaps with a broken limb, his own hands and those of his comrades grimed with mud, and no one knowing till clothing is removed where the wounds are situated or how numerous they are, it becomes evident that to apply antiseptics under these conditions is worse than useless; and no one familiar with these conditions would ever think of advising such treatment. It is indeed clear that the very best thing is to get the patient away as soon as is possible to some place where he can be thoroughly treated and kept in safety for a sufficient time, and in the British army that place is in some cases the field ambulance, and in all the worst cases the casualty clearing station.

It is at this stage that we find there are two different schools of thought amongst those who are not at the front, as to what is best to be done in the treatment of the wound. One school, which draws its experience mainly from the surgery of civil life, would persuade us that all our wounds, if properly treated, should be completely sterilized—at a single dressing if seen early enough—by the application of this or that antiseptic agent; and in any subsequently septic wound can only see evidence that the surgeon's work has not been done as well as it ought. The other school, which draws its limited experience from this present war, asserts that antiseptics are useless as such, and considers that they should not be used at all.

I am myself very decidedly of the opinion that neither school is right, and that, on the one hand, the badly-infected wounds in badly-injured men can seldom be completely sterilized at a single dressing; and, on the other hand, I am quite certain that antiseptics are useful and necessary for the proper treatment of all the wounds of war, and that they have been of the utmost service.

Experience in Civil Practice.—For many years I have been on the staff of St. Bartholomew's Hospital, and I have seen both the end of the pre-antiseptic days of surgery, and the whole of the antiseptic period since Lister's views became generally accepted. I have seen many changes in methods and practice, and I know full well that in each succeeding decade the results obtained by surgery have been better and better.

Consider for a few minutes what is the practice which is commonly accepted as correct for a bad compound fracture of the leg caused by the wheel of a heavy vehicle. My own house surgeon would proceed much as follows: The patient would be deprived of his dirty clothes and washed, and would then be taken into an operating theatre where everyone would wear sterilized gloves and gowns. His skin would be shaved and washed with acetone or ether, and then painted with a 2 per cent solution of iodine in spirit. The wound would be enlarged if necessary; the dirty ragged skin

edges and bits of torn muscle would be cut away; sufficient drainage would be provided; loose bone fragments would be removed; the whole wound would be thoroughly washed again and again with a solution of biniodide of mercury (which I prefer to perchloride because it does not coagulate albumin); sterilized or cyanide gauze would be applied; and splints would be fitted to the limb.

And what would be the result? In my experience, in nine cases out of ten the fracture would heal as well as if there had been no wound, and the wound itself would heal either by first intention, if not too lacerated, or else by granulation, with the minimum of suppuration, if it was extensive and if some of the skin had been destroyed. What has the treatment effected? I should reply that it has at least mechanically cleansed the wound, without adding to its previous contamination any microbes on the hands of the surgeon or on his instruments; and that further, it has rendered harmless any bacteria in the skin of the patient, and has both mechanically removed organisms already in the wound, and has temporarily inhibited the growth of those remaining, so that the healthy tissues could quickly destroy them.

And if I am told that the antiseptics I have employed to the skin and to the wound itself have played no part, and that sterilized water would have done as well, I should reply that I know by experience that until we did use antiseptics very thoroughly we did not get these results, and that the wounds which have been treated in the manner described have done consistently better than those of previous years. I should add that practical experience has shown that suitable dilute antiseptics have never done harm, and that consequently there can be no possible objection to their use.

But if, on the other hand, I am taken to task as to why we cannot get as consistently good results in war as in peace, my answer is to be found in what I have said—namely, that, in the first place, neither the conditions of the patients themselves nor the character of their wounds are at all comparable; and in the second, that the microbic infection is also quite different from that in civil life.

THE USE OF ANTISEPTICS.

And if the question be asked, Are then antiseptics to be used in the case of recently wounded men, and if so, what good can be expected from them? I should unhesitatingly answer that, whenever possible, all these soiled wounds should be treated just as carefully and thoroughly by antiseptics as any dirty wounds would be in any great British hospital; and that exactly the same amount of good is to be expected in recent gunshot injuries from the cleansing of the skin and of the wounds. The ordinary pyogenic organisms, at least, can be eliminated in sufficiently early and favourable cases, and the patient has, in consequence, a much better chance in his fight against his new enemies. If we cannot kill all the bacteria, there is no reason why we should not kill as many as we can; and, as we have in civilian practice already succeeded in sterilizing, for all practical purposes by a single dressing, very many of the septic wounds which we habitually treat, we naturally do not credit those who assure us as a result of experimental evidence that this cannot be done; so we not unreasonably hope that we are already succeeding in finding better methods

than we have hitherto possessed for the wounds of war and the anaerobic and fæcal infections. I altogether object to the attitude that antiseptics never have and never will overcome early sepsis.

The line of treatment I have indicated above, with minor variations, such as more extensive excision of injured tissue, has been carried out in thousands of patients in this war; and I claim that practically all those who have had slight wounds, as well as many who have had serious wounds, have done exceedingly well. We have, indeed, had abundant evidence of this, both in the way our patients have recovered, and also in the numbers of wounded men who have returned to the colours; and it should be a satisfaction to everyone to know that, except when overcrowded by the rush of frequent battle, the conditions for the treatment of the wounded in well-equipped operating theatres are not one whit behind the best that can be found in civil life. No better work has been done during this war in the saving of lives and limbs than the thorough cleansing and dressing of severe wounds, whether complicated by fractures or not; and except for the very great difficulties, inherent in warfare, which I have already described, there is no more delay in conveying the patient to field ambulances and clearing stations than in getting a patient from an accident into a civilian hospital. I am also quite certain that it is most inadvisable to teach that no wound can ever be sterilized by the proper use of antiseptics; for in the first place the statement is contrary to the experience of surgeons for many years past, and in the second it is liable to discourage well-intentioned efforts.

Shell Wounds and Bad Fractures.—But if it be asked whether the treatment I have advised can be relied upon to sterilize completely the large lacerated shell wounds and the bad compound fractures, the answer must be that, up to the present time, neither this nor any other treatment yet adopted and described in the armies of the enemy or of the Allies can claim to have accomplished this, in the particular class of injury to which I allude, by any single dressing or cleansing, even when the wound is treated at once. It is indeed a notable fact, that no surgeon who is familiar with the wounds and conditions at the front has ever made such a claim: and it is those who only know these wounds subsequently, who are prepared with antiseptics, which have each failed when put to trial. And it is for this reason, and with this knowledge, that we who see these men soon after injury, say that such wounds should never be treated as if they had been rendered aseptic, and as if they could be safely closed. There is, of course, no doubt that slight and simple wounds may be so completely excised that all infected tissue is removed, and all the surrounding skin cleansed so thoroughly that primary aseptic union may ensue in a large percentage; but no such result as this has been obtained in the very large lacerated wounds where complete excision is an impossibility, as a routine consequence of any method of disinfection at a single dressing. The best we can reckon on is that after several or many days, the wounds may become free from dead tissue and virulent bacteria.

It is especially in these cases of bad compound fractures, and lacerations by shells, that free drainage is so absolutely essential; and my colleague,

Surg.-Gen. Sir George Makins, directed special attention to the need for this very early in the war; Col. Burghard and Lieut.-Col. Sargent were each subsequently insistent; yet in spite of this, it was some time before we could get free drainage universally adopted at the front. And for the following reason. It became evident that some of the most recently qualified medical officers had been so much accustomed to deal with clean wounds which could be safely sutured, and had got so accustomed to obtaining union by first intention, that they could not believe that the gunshot wounds they treated had not also been satisfactorily sterilized. The fact is that, owing to the very success attending the practice of surgery in recent years, there was a certain amount of ignorance of septic wounds, an ignorance which is easily accounted for when one considers how very little suppuration is found in the wounds in all hospitals of the present day. But when sutures were finally given up and large drainage tubes were used freely, the wounds did better, and the stimulus supplied by the work of Col. Sir Almroth Wright was of inestimable value in promoting sound practice on these lines. Let us clearly recognize, however, that the provision of efficient drainage is no new thing; and that it is of course quite easy to appreciate its benefits in the infections by anaerobes, when we remind ourselves of the fact on which I have already laid stress, that the anaerobes live mainly in dead tissue, and are quickly killed by healthy cells. It is not material whether they find dead muscle or dead fluid, and the principle that septic wounds should be drained was an established practice of surgery, and thoroughly understood in all its bearings, long before the present war supplied so large a field for its use.

Treatment of Cases of Advanced Sepsis.—But while we should strive to cleanse all recent wounds, it must constantly be borne in mind by military surgeons that the longer the time that elapses between the infliction of the wound and the first thorough dressing, the more impossible does it become to obtain a good result. I have already pointed out the many reasons why and how this delay is so fatal; but all lead finally to one paramount reason—namely, that the longer the wound is left in its primitive state of blood-stained and crushed tissues contaminated by a bacterial-laden soil and muddy clothes, the more extensive and far-reaching is the growth of these micro-organisms, and the more impossible does it ultimately become to attack them with any hope of immediate success: the more likely also is the patient to be already infected beyond hope of recovery; and I have known men who, before they could be rescued, were already dying from the results of the infection by gas-forming organisms. How, then, are we to treat cases where advanced sepsis is definitely established beyond hope of early sterilization?

We have the choice between the hypertonic salt solution of Sir Almroth Wright, and the use of antiseptics, and each of these has many supporters. The object of each is the same in reality; for it is recognized by advocates of both that it is necessary for dead tissue to be disintegrated or cut off as sloughs, and for granulation tissue to grow, before healing can take place; and as one watches the blood-stained unhealthy discharge from the dead and dying tissues give place to the formation of pus by healthy granulations, one appre-

ciates more clearly than ever before, why the older surgeons spoke of "pus laudabile et bonum." They understood that when the velvety granulations and the creamy fluid appeared, destruction had ceased and repair had begun; and we recognize to-day, as they did, that there is such a thing as a relatively 'healthy suppuration.'

I think that those who prefer antiseptic to saline treatment have found, as in all sloughing wounds and cellulitis of civil practice, that nothing is so good as prolonged immersion in an antiseptic fluid; but unfortunately most wounds are not so situated that this is possible. When this is the case, the next best thing is to employ constant irrigation; and very many wounds have done exceedingly well under this method, whether saline or antiseptic fluids have been used. But whatever fluid is employed, every surgeon knows by experience, which is far more valuable than any other source of information, that good results in a complicated wound can only be obtained if the treatment of the wound is varied according to its condition. It could only be inexperience of wounds that would limit a surgeon to a single form of lotion, and it is the merest truism to say that in complicated and septic wounds a change of lotion or other application is as necessary as is a variation in the diet of the patient.

It has seemed to me that the period during which the saline hypertonic treatment is useful is strictly limited to the separation of sloughing and unhealthy tissue; and that once a granulating surface is obtained throughout, it had better be abandoned, for it is generally painful, and if it is continued the skin becomes irritated, the granulations often become exuberant and flabby, and the healing process is correspondingly slow. The use of such well-tried applications as nitrate of silver and sulphate of zinc may then well prove more beneficial than that of the most potent solution of antiseptics or salines; for to treat wounds according to the daily report on their microbic infection, to the neglect of all else, is as foolish as it would be to treat every symptom of an illness rather than to treat the patient who is ill.

Within the past few months the treatment by solutions of hypochlorous acid has been most extensively tried, and the methods of producing it, advocated by Dakin and Carrel, and Lorrain-Smith, respectively, seem to most observers to be equally good. Personally, I may add that, as far as I have seen, there is nothing to choose between the two solutions; and I think I may safely say that very many surgeons are pleased with the results obtained by the early treatment of recent wounds, and have given up other methods in its favour. Where wounds of the hands and feet have been immersed in the solution, they have cleared up with great rapidity; and where extensive lacerated wounds and bad compound fractures have been treated by irrigation, many patients have done extremely well. I think that wounds of this class have done better under treatment by hypochlorous acid than under any other; but I cannot say that they have become sterilized as rapidly as the cases recently described by Carrel; and I do not think that the good results he obtained were in wounds of the class I specially refer to, namely, extensive lacerations by shells, and bad compound fractures. It is, however, my very decided opinion that the hypochlorous acid treatment is an important advance, more especially when used in recent wounds before suppuration has occurred;

and I find that it has to a great extent displaced all other forms of treatment in many of the casualty clearing stations. It is generally believed to have prevented the occurrence of gangrene in many bad lacerated wounds, and to have arrested its progress in others; and, although I am well aware that it has not always been successful, I consider that it has already been productive of very much good, and that it is more useful in this class of wound than any other application we have yet tried. It is also a very remarkable fact that, unlike most antiseptics, it can be used in solutions sufficiently powerful to destroy virulent microbes very quickly without at the same time injuring the tissue cells. It should, however, be only employed in solution; for if used as a powder, it is liable, like many other powders, to form hard lumps which obstruct free drainage, and so counteract its good effects.

I have now, Mr. President, completed the task I set myself at the beginning of this lecture, and I have placed before you as well as I am able, in so brief a space of time, the circumstances and conditions of our wounded soldiers in France and Belgium, and the nature and treatment of their wounds.

But there remains yet a duty which I feel I owe both to the army itself and to the medical profession at large, and that is to express to you how deeply I feel the whole country is indebted to the medical officers in whose hands are ultimately placed the duties of caring for our sorely-tried soldiers.

I do not propose to say one word about the general efficiency of the corps to which I have the honour to belong, for it needs no words of mine. What I do wish to say is, that nothing has impressed me so forcibly or so favourably as the qualities of many of the younger surgeons on whom has rested the chief stress of the actual treatment of the wounded. There is not a medical school in Great Britain or Ireland that has not reason to be proud of its pupils; and the work of the surgeons has been equalled and supported by that of their pathological colleagues.

I do not know whether to admire most the energy and keenness which has enabled the staffs to work days and nights without adequate rest, or the technical surgical skill, in complicated and difficult operations on the abdomen and limbs alike, which has been so conspicuous a quality in so many officers. The care, and zeal, and patience, displayed in efforts to save limbs and life have been no less praiseworthy than operative dexterity.

The Royal College of Surgeons has influenced and guided the teaching of surgery during many years, and all who have shared in this responsibility may feel a legitimate pride in the splendid work now being done by its pupils. "The tree is known by its fruit"—and the future of British surgery is in safe keeping, for many of the best brains and hands which guide its course are yet young.

THE TREATMENT OF PENETRATING WOUNDS OF THE SKULL.

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Of the many problems connected with gunshot wounds of the head, as seen in the present war, one of the most difficult, as well as one of the most common, is the treatment of those cases in which fragments of bone, either alone or along with pieces of metal, have been driven to a variable depth into the brain substance. These conditions may arise from various types of wounds, which may be classified as follows :—

A.—Tangential wounds in which the missile, usually a rifle bullet, has passed superficially to the bone, leaving its mark externally in the form of a gutter in the scalp, or of two wounds with a bridge of skin between them. Tangential wounds of this kind may cause no fracture at all, or merely a slight depression of the inner table without laceration of the dura mater. In the more severe cases, however, the bone is comminuted, and the dura lacerated, whilst at the same time fragments of bone are driven into the brain substance, though rarely to any great depth. It is only the more severe of these wounds to which we desire to draw attention here—those, namely, in which the dura and brain have been lacerated by in-driven fragments of bone.

B.—Penetrating wounds in which the missile has passed immediately beneath the bone, along the chord of a small arc. In these cases laceration of the dura and brain is naturally inevitable ; and although the bony fragments are for the most part driven outwards, yet some may at the same time have penetrated more or less deeply. These wounds often result in the destruction of an area of cerebral cortex which is relatively large in extent as compared with its depth, presenting a condition for which some operation of covering-in the exposed brain, combined with free drainage, may be adopted. The operation which we are accustomed to perform in this class of case is described below.

C.—Direct localized blows by fragments of shell or shrapnel bullets which have themselves failed to penetrate the skull, but which nevertheless often drive fragments of bone deeply into the brain, so deeply in fact that even if the ventricle is not actually opened, its proximity to the septic track is such as to render its infection highly probable. In many of our fatal cases post-mortem examination has shown that this condition existed. In removing fragments of bone from any depth, the position of the lateral ventricle should always be kept clearly in mind, lest it should be accidentally opened in the course of the operation. These remarks apply with even more force in the next class of cases.

D.—Penetrating wounds in which a missile has entered, and remained lodged within the brain substance. Rifle bullets, shrapnel bullets, and fragments of shell may all produce this class of injury; the missile may be broken up, and several pieces may be buried in different parts of the brain. In these cases bone fragments are always in-driven in addition, but they remain as a rule superficial to the pieces of metal. The question of removing these foreign bodies will be discussed later.

E.—Cases in which a rifle bullet has passed across the cranial cavity, the wounds of entry and exit being on opposite sides of the head, or so far apart that the intervening bone is undamaged, or at most only fissured. Here it is only at the entrance wound that fragments of bone are in-driven; and as the bony opening is usually only a small puncture, the fragments are often mere splinters. These cases are mentioned here because they have certain features in common with those of the foregoing classes. It is rarely, however, that any operation which involves searching for splinters and drainage of the track is required in such cases; and patients shot through the head by a rifle bullet who escape immediate death, usually, as is well known, recover well without operation.

SYMPTOMS.

Before discussing the treatment of the cases included in the above-mentioned groups, it will be well to consider the symptoms in so far as they bear upon the question of treatment. The immediate result of a severe gunshot wound of the head is a group of symptoms due to a widespread disturbance of function affecting in varying degree the whole cerebral and bulbar mechanism. Loss of consciousness of varying depth and duration, general muscular flaccidity, and disturbance of cardiac, respiratory, and vasomotor action, are amongst the most striking of these general symptoms; but their exact pathological or mechanical basis is still imperfectly understood. Whatever it may be, it results in a suspension or disturbance of function from which (except in patients who die outright or within a few hours) recovery can take place spontaneously. This is the stage of 'concussion' or cerebral shock, and its symptoms differ in no essential respect from those which result from non-penetrating wounds, and which are familiar in the cranial injuries of civil practice.

Associated with these disturbances we find a group of symptoms due to the abnormal increase of the intracranial pressure. This is the stage of cerebral œdema, and its effects may be aggravated by the presence of effused blood, which either mingles freely with the excessive cerebrospinal fluid, or may be more or less localized or circumscribed. The experience of a large number of cases has shown that such hæmorrhages are very rarely large enough either to threaten life or to demand operative interference. Whilst the possibility of extensive bleeding must be remembered, it must not be permitted to loom too largely. When hæmorrhage of any consequence does occur, it is as likely as not to be basal, contralateral, or inaccessible; it manifests itself, if at all, after an interval of many hours or even several days; and it almost always gives rise to definite localizing symptoms superadded to those of the general compression. The possibility of a hæmorrhage sufficiently

large to demand, and sufficiently localized and accessible to be amenable to, direct operative treatment, is therefore so remote that exploration on this account is rarely desirable, more especially in view of the danger of infection which would be incurred from the presence of a septic scalp wound. The stage of cerebral œdema may last for several days, and in the absence of a spreading infection, subsides spontaneously. If severe and prolonged, the symptoms may be relieved by lumbar puncture, a procedure, however, which in cases where the dura is lacerated, carries with it certain special risks which will be dealt with presently.

In addition to the symptoms of *general* cerebral disturbance of function, those due to the *local* damage must be taken into account. Evidence of the local injury is afforded by disturbances of motor, sensory, reflex, mental, and visual functions, according to the region involved. Such impairment of function depends partly upon actual destruction of cerebral tissue, and partly upon contusion, localized œdema, or local 'concussion': from the effects of the former no improvement can be obtained by operation, whilst that part of the symptom-syndrome due to the latter causes is capable of more or less complete recovery without surgical interference. As it is not possible at first to say how great a share the one or the other contributes to the clinical picture, no accurate prognosis can be made. It is certain, however, that operative interference cannot directly benefit either condition, and recovery of function is sometimes wrongly ascribed to the operation which precedes it. On the other hand, any progressive loss of function usually points to the necessity for affording free drainage of the damaged brain, as it may be due to a secondary inflammatory process which may lead to an extension of the area permanently damaged.

In many respects all these penetrating injuries are alike: they present similar difficulties, are attended by the same dangers, and offer similar problems. It is easy to regard them merely as compound fractures complicated by injury to underlying structures, and to assume that they require exactly the same treatment as compound fractures in general. This view holds good so far as the essential point of eliminating infection is concerned, but the problem is by no means so simple as at first sight it appears to be. How to secure efficient drainage of the damaged brain is one of the chief difficulties, and this arises principally from two facts: firstly, that the brain swells so easily in response both to traumatism and to inflammation; secondly, that the amount of extra room which the cranial cavity is capable of affording is so small in relation to this swelling.

Other differences between these injuries, and compound fractures elsewhere, are also apparent. In the latter, the bone is at once the deepest and most important structure concerned; interest is chiefly centred upon the possibilities of osteomyelitis and septicæmia, and upon how well, and in what position, union of the bone will take place. With head injuries the bony lesion is a matter of subsidiary importance; osteomyelitis is rarely seen, and all the damaged bone can be cut away without any great disadvantage to the patient; whilst its superficial position makes drainage easy. Too much stress, therefore, should not be laid upon the fact that in gunshot wounds of the head we are dealing with compound fractures; attention must rather be focussed upon the

wound of the brain, in the infliction of which a certain amount of bony damage has of necessity been done.

TREATMENT.

In the type of injury which we are considering, all grades of severity are met with, both as regards the superficial extent, and the depth of the cerebral laceration. As regards the operative details, however, these cases may be looked upon as falling into one of two groups, according to the depth to which bone fragments have been in-driven and to which brain tissue has been damaged. In the first and larger group are found those cases in which the scalp wound, bone defect, and dural opening are comparatively small, but in which the underlying brain has been penetrated and lacerated to such a depth that, after removal of bone fragments, the track requires drainage by a tube. In the second are included those in which the dural laceration and the cerebral injury are greater in extent than in the former group, but are comparatively superficial—where, in fact, after cleaning and removal of bone fragments, no track into the brain exists into which a tube could be inserted.

To these two groups different types of operation are applicable, but it is not always possible to tell beforehand which type will be required in any individual case. Usually, however, the depth of the cerebral injury can be estimated with some precision by consideration of (*a*) the mode of infliction and appearance of the wound; (*b*) the neurological symptoms; (*c*) *x*-ray examination.

The time at which operation should be undertaken is a matter of very great importance, and one upon which opinions vary. In considering the question, it is necessary to have a clear conception as to what ends are to be attained by the operation, and in what manner it is expected to benefit the patient. Two main considerations must be taken into account—namely, the cerebral injury as such, and the presence of an infected wound. As regards the neurological symptoms, operation is rarely if ever called for at an early stage, and seldom at a later one. As has already been pointed out, the symptoms of cerebral injury fall under two heads, that of general compression and that of local derangement of function: the former, unless due to progressive hæmorrhage, does not require relief by operation, and can almost always be kept within bounds by repeated lumbar puncture; whilst loss of function in the part of the brain directly affected is due partly to shock effect, from which spontaneous recovery will take place, and partly to actual destruction, which cannot be benefited by any operation. As regards the neurological symptoms, therefore, immediate operation, in the vast majority of cases, is not indicated. From the point of view of the wound itself, it would naturally seem at first sight that immediate operation would offer the best prospect of recovery and prompt healing; and this would doubtless be true but for two special circumstances: firstly, the ease with which the subarachnoid space can be infected; secondly, the tendency which exists towards the formation of a hernia cerebri. Experience has shown that delay minimizes both these dangers, as may be appreciated from the following considerations.

Firstly, as regards *meningitis*: The chief safeguard against a generalized meningeal infection is the formation of adhesions between the edges of the

dural wound and the contiguous pia-arachnoid, by which means the subarachnoid space is shut off; this process is assisted by the pressure of the swollen brain against the dural opening. If an operation is done at a very early date, before these adhesions have formed, the subdural space will probably be infected, and a generalized superficial meningitis will result. Further, the removal of damaged brain tissue from the track, together with the fall of blood-pressure due to the operation—particularly if chloroform is administered and much blood is lost—may result in a temporary shrinkage of the brain, so that it tends to fall away from the dura mater, and thus open up the subarachnoid space. After recovery from the operation, the rise of blood-pressure and the additional traumatic œdema cause the brain again to press tightly against the opening, leaving infective material imprisoned in the subarachnoid space. The more firmly the subarachnoid space is shut off by adhesions at the time of operation, the more safely can the operation be undertaken.

Secondly, as regards *hernia cerebri*: When the intracranial pressure is raised, and there exists a defect in skull and dura mater, brain matter tends to be extruded. In the early or concussion stage the brain is swollen from traumatic œdema, and consequently the intracranial tension is raised considerably above the normal; any fresh manipulation is followed by a further rise in pressure; with any meningeal infection the pressure is still further increased. The tendency for brain matter to protrude through the opening is in direct relation to the degree of intracranial pressure, and consequently protrusion is more likely to occur when the brain is manipulated in the presence of the initial traumatic œdema. If the operation is delayed until this initial œdema has wholly or even partly subsided, the tendency to protrusion, i.e., to the formation of a hernia or fungus, is diminished. The appearance of a hernia cerebri is evidence of an abnormal degree of intracranial pressure; as long as this pressure remains stationary the hernia does not alter in size; any increase in pressure at once leads to an enlargement of the hernia; whilst as soon as the pressure falls to normal the protrusion disappears. These herniæ, however, do not consist of normal brain, as do those protrusions which are deliberately established by a properly executed decompressive operation, as in cases of tumour or of hæmorrhage. In the latter the opening in bone and dura is large enough to afford complete relief of the tension without any undue pressure of the brain against the edge of the opening. When the latter is insufficient for complete relief of tension, the cortical veins at the edge of the opening are obstructed, and the protrusion becomes œdematous. It suffers in consequence; its function is impaired and ultimately destroyed; a still further degree of strangulation leads to gross necrosis and sloughing. It is not, however, only the brain in the hernia which suffers. The brain still within the cranium and in the neighbourhood of the opening also becomes œdematous from the venous engorgement; this not only favours a further increase in size of the hernia, but leads also to functional impairment of the œdematous brain. Further, the lining of the ventricular cavity tends to herniate, first into the overlying softened brain, and then into the base of the hernia cerebri: ultimately it may rupture and discharge cerebrospinal fluid. Ventricular infection rapidly follows. The formation of a hernia cerebri is therefore not only dangerous to life, but also to function—the function not only of the brain

actually protruded, but also of that part which lies in the neighbourhood of its base.

This danger, then, provides a second reason against immediate operation. Naturally there is some risk in allowing bone fragments, which may be infected, to remain buried in the brain, because an infective encephalitis may spread from such a focus and may reach the ventricle. The respective dangers, those of meningitis and of hernia formation attendant upon the earlier operation, and that of ventricular infection which besets delay, have to be balanced against one another; but the experience of a large number of cases has gone to show that the dangers of the earlier operation are greater than those of the procedure about to be described, undertaken after from three to five days. Further, it must be remembered that an *x*-ray examination is an essential preliminary measure. An anteroposterior and a lateral picture may together be sufficient; but for accurate determination of the position and depth of the in-driven fragments, the information so obtained is in our opinion not to be compared with that given by stereoscopic examination. Any search for fragments of bone or metal, in the absence of a radiographic examination, is inadvisable. The procedure about to be described is applicable whether a piece of metal is found to be present or not.

The question of the removal of metallic fragments is difficult to decide, inasmuch as their ultimate fate and their possible effects upon the surrounding brain are at present uncertain. Such evidence as has accumulated up to the present time seems to show that foreign bodies are best left alone unless they are so superficial as to be easily removed along with the bone fragments; or unless at a later period they cause symptoms directly referable to their presence. It must be borne in mind that such symptoms as exist at first are not due to the mere presence of the foreign body; they depend upon the injury done during its introduction; and its removal will not only fail to effect any improvement, but, from the additional damage necessarily caused during the operation, those symptoms are more than likely to be aggravated. Further, and with reference to the danger of abscess formation or diffuse cerebral softening, such metallic fragments are not always septic; several which we have removed have been dropped immediately into culture media, in which, under both aerobic and anaerobic conditions, they have failed to provoke any growth whatever. If abscess formation occurs later, it is much more likely to arise in some part of the track along which the fragment has passed, and in whose walls hairs and other septic material have been implanted.

The question of removal will be further influenced by the nature, position, and number of the metallic foreign bodies. Clearly, many lie in positions inaccessible to legitimate surgery; or again, the relative positions of wound and foreign body, taken together with the symptoms, show that in its passage such damage must necessarily have been done as to render the chances of recovery hopeless. Further, *x*-ray examination often shows that many fragments are scattered widely throughout the brain, so that their removal is impossible.

Two further considerations make one hesitate before removing even easily accessible pieces of metal. Firstly, although several patients have

made good recoveries after removal, several others have died, undoubtedly as the direct result of the operation. Secondly, many patients in whom removal was not attempted have gone home with good prospects of recovery, and several of these of whom we have since heard are still, after many months, doing well and with the wounds completely healed.

If it is decided not to remove the foreign body, the wound of entrance must nevertheless be dealt with as efficiently, and upon the same lines, as if no foreign body were present.

The steps of the operation which we have found to give the best results will now be described. The whole scalp is cleanly shaved, thoroughly rubbed over with gauze dipped in alcohol, and painted with 2 per cent iodine-spirit; the wound shares the same treatment. When the position of the operative field is convenient, a tourniquet of rubber drainage tubing is tied tightly round the head below the inion, and immediately above the auricles and eyebrows: to prevent the band slipping down over the brows, and possibly damaging the eyeballs, it is secured to the scalp by a couple of sharp-pointed skin clips. The operation is conducted from start to finish under a rapid stream of hot normal saline solution. This is an important point, as much softened brain and infective material is washed away, and at the same time the operative field is kept unobscured by blood.

The next step is to excise the edges of the scalp wound just beyond the limits of visible bruising and laceration of the skin; any torn and bruised aponeurosis or muscle can be cut away from beneath after turning down the flap. A large flap is now cut, the shape and size of which necessarily vary with the position and size of the wound which occupies its centre. It should be large enough to expose an area of bone well beyond the limits of the bony opening which is to be made; it is better to make too large than too small a flap.

The opening in the bone is now enlarged so as to expose the dura mater for at least half an inch all round the dural wound. Usually it is best to make a trephine hole alongside the bony opening, and to work from this; if one attempts to enlarge the existing opening by inserting a forceps blade beneath its edge, there is considerable risk of producing further damage and of disturbing the adhesions between dura and pia-arachnoid at the edges of the dural wound. Any loose fragments of bone are next picked out, and then the finger is very gently inserted through the dural wound into the softened disintegrated brain. Directly a bony fragment is felt, it is picked out with dissecting forceps. This procedure is persisted in until all the fragments have been withdrawn. It is of the utmost importance not to enlarge the dural opening, which is almost invariably of sufficient size to permit of the necessary manipulations. At this stage it almost always happens that, with the escape of softened brain and the removal of the bony fragments, the general intracranial tension is less than at the beginning; the dura pulsates more freely, and further escape of particles of brain and blood-clot takes place. This cleansing is assisted by directing the stream of hot saline upon the opening, a proceeding which at the same time checks and arrests any bleeding that may be present.

The track having thus been cleansed as thoroughly, and at the same

time as gently, as possible, now requires drainage. The tube which we have found, after several experiments, to answer the purpose best, is a cylinder of perforated metal (zinc, aluminium, or copper), $1\frac{3}{4}$ inches long and $\frac{3}{8}$ inch in

FIG. 151.—PERFORATED METAL DRAINAGE TUBE.

diameter (*Fig.* 151). This tube is very carefully inserted into the track, and the flap is replaced and sutured, a small drain of rolled rubber sheeting being inserted between two stitches at each inferior angle. By the time that the

FIG. 152.—The original wound has been freely excised, and enough bone has been removed to expose the dura mater beyond the limit of its laceration.

flap suture is completed, it is usually found that a certain amount of disintegrated brain has already been squeezed into the tube through the lateral holes. This material is removed by means of a small curette, still under

the saline stream. The lumen is now dried out with gauze strips, and filled with sterilized glycerin; finally, a packing of gauze soaked in glycerin is placed around the tube, and a large dressing of gauze and wool is applied. Glycerin has proved to be the best application; it is hygroscopic, and consequently appears to act in a manner similar to that of a hypertonic salt solution; it has an inhibitory action upon the growth of pyogenic cocci; and it seems to emulsify and to facilitate the escape of the disintegrated brain substance. If the intracranial pressure is so high that the tube tends to be extruded, a little cerebrospinal fluid is withdrawn by

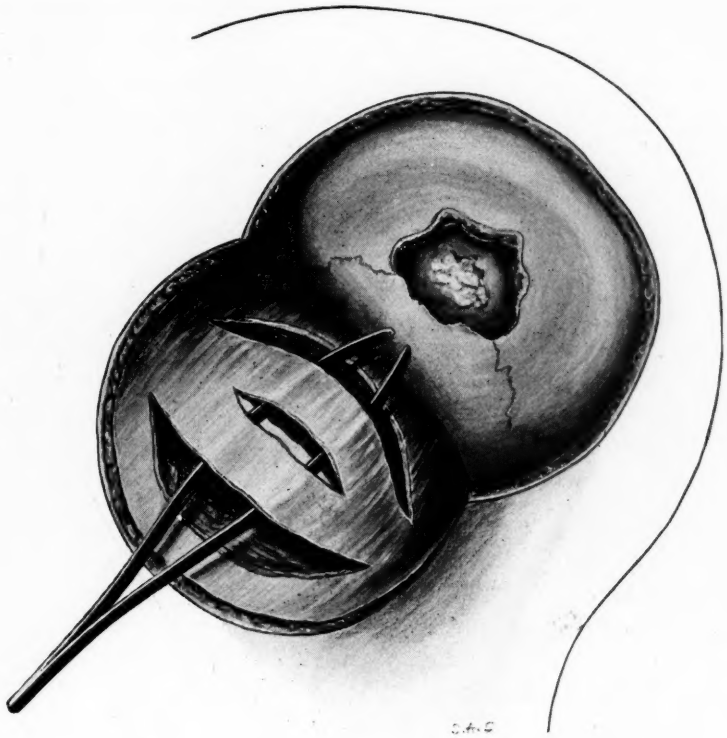

FIG. 153.—The pericranio-aponeurotic flaps have been fashioned and separated from the skin..

lumbar puncture; and this process can be repeated from day to day, or as often as the degree of intracranial tension requires it. At the subsequent daily dressing the contents of the tube are removed by curetting and syringing; the interior is then dried out and again filled with glycerin. The tube is allowed to remain in for about a week, but at each dressing it must be gently rotated, lest it become fixed by granulations or brain matter projecting through any of the holes in its wall. It is not extruded unless the intracranial pressure is unduly raised, and thus any tendency to extrusion is to be regarded as an indication for lumbar puncture.

Removal of Shell Fragments and Bullets.—In a certain number of cases we have considered it advisable to remove these foreign bodies, especially when they lay in comparatively superficial and accessible positions. It is of course necessary to recognize the fact that such operations entail a certain amount of additional damage to the brain, as well as the risk of spreading infection. It is therefore essential that the utmost gentleness should be used, to avoid these accidents as far as possible. We have found that in the case of magnetic metal—namely, fragments of shell and German bullets, which together constitute by far the largest number of such foreign bodies—the use of a giant magnet has enabled us to effect the removal with a smaller amount

FIG. 154.—The flaps have been sutured, so as to form a complete 'floor' for the scalp wound.

of manipulation and damage than is possible when scoops and forceps have to be employed. For the obtaining and setting up of this magnet, we are indebted to Lieut. Gamlen, Radiographer to No. 13 General Hospital. The instrument is a large Haab's magnet, wound for a voltage of 220, and 8 ampères (we had to have it re-wound to accommodate the 100-volt current of Boulogne). The current is switched off and on by the operator's foot. This magnet was made to carry a weight of six hundred pounds, so that its pull, even when greatly diminished by the length of rod used to connect it with the foreign body, proved to be of ample power.

It was found that if the nose of the magnet was brought close to the brain, and the current switched on, the foreign body was not necessarily drawn

along the track through which it had entered, but might be pulled along some other, and perhaps more direct, path through uninjured brain. This was clearly a source of danger, to avoid which we used soft iron rods, 12 to 18 cm. long and 1 to 1½ cm. in diameter, for the purpose of connecting the magnet with the foreign body along the track of entrance. When in action the magnet has a pull of several pounds along these rods, and can attract a piece of metal along the track in the brain even when distant an inch or more from the point of the rod.

The exact method of procedure is as follows: The operation is carried out as previously described, up to the point at which all the bony fragments have been removed from the track. The magnet, covered with a sterilized

FIG. 155.—The operation completed, showing the wound 'floored,' and the method of drainage.

towel having a hole in its centre to allow of the passage of the cone which forms its nose, and which has previously been sterilized, is now brought as close to the patient's head as possible. The soft iron rod is pushed gently along the track in the brain until it is thought to be close to the foreign body; the nose of the magnet is then brought into contact with the rod, and the current switched on. In some cases a distinct click is heard when the foreign body is attracted to the rod. After allowing the current to remain on for a few seconds, the rod is gradually withdrawn from the brain, keeping it of course in contact with the magnet, and bringing the foreign body with it. A steril-

FIG. 156.—LARGE DEFECT IN SCALP FROM A SHELL WOUND. —The patient exhibited no symptoms of cerebral injury, and an operation was undertaken solely for the purpose of assisting the healing of the wound. The dead bone was removed and the gap in the scalp was floored by the method shown in *Fig.* 154.

FIG. 157.—THE OPERATION UPON THE WOUND SHOWN IN FIG. 156 COMPLETED. The 'floor' rapidly became covered with granulations, and the wound healed well.

ized test tube is now brought beneath the foreign body, which falls into the tube as soon as the current is switched off.

It is necessary, before turning on the current, to cover up with towels all the instruments in the area of the wound, or they will fly up to the magnet and disarrange the whole field of operation in a most embarrassing fashion. Another practical precaution is to remove all watches from the theatre; many suffered damage during the experimental stages.

FIG. 158.—THE WOUND SHOWN IN FIG. 157 THREE WEEKS AFTER OPERATION.

Superficial and Extensive Laceration of the Brain. — Where no track exists into which a drainage tube could be inserted, the operation may with advantage be modified in such a manner as to cover over the exposed lacerated brain. Treated in this way, many cases have healed more rapidly and with less risk of secondary infection than if they had been left with a large raw surface to heal by granulation. The operation is carried out exactly as that hitherto described, up to the insertion of the drainage tube (*Fig.* 152). A plastic operation is then performed in the following manner, so as to close the gap which has resulted from excision of the original wound. In the temporal region it is easy to secure flaps of muscle, but elsewhere the pericranial and subcutaneous tissues must be used. Working upon the cranial

aspect of the scalp flap, the pericranium and aponeurosis are dissected up from the skin on either side of the wound for a distance of considerably more than half the size of the area to be covered in (*Fig.* 153). Two flaps with pedicles are thus fashioned, and are brought together edge to edge with a fine catgut suture so as to form a complete floor to the wound (*Fig.* 154). It is important that they should be as thick as possible, with broad pedicles, and that they should be sufficiently large to cover the wound without tension. Drainage is provided by laying two fenestrated rubber tubes along the dura mater immediately below the cerebral laceration, and bringing out their ends at the lateral angles of the scalp flap (*Fig.* 155). The lacerated brain, though not

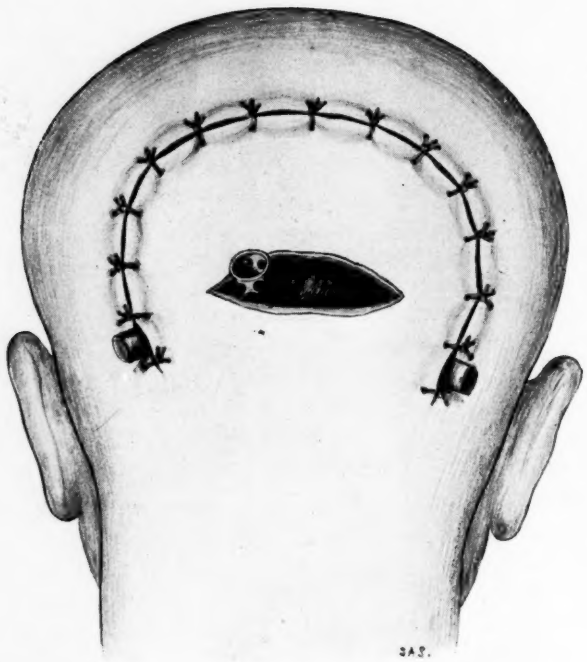

FIG. 159.—Gap partly closed by an aponeurotic 'floor,' leaving sufficient room for the passage of a drainage tube.

exposed, can be washed by syringing through these tubes at each dressing, and at the same time ample drainage is provided. The tubes are allowed to remain in place for about a week. In consequence no doubt of faulty technique, a few of these aponeurotic flaps have sloughed; but the majority have remained alive, and have assisted materially in the rapid healing of the wound. (See also *Figs.* 156, 157, and 158.)

The Combined Operation.—In some cases the gap left by excision of the original wound is larger than is necessary for the passage of the drainage tube. In these cases the gap may be partly closed by an aponeurotic floor, as in *Fig.* 159.

Lumbar Puncture.—Our experience has shown that lumbar puncture is one of the most valuable aids which we possess in the treatment of gunshot wounds of the head. We cannot here discuss all its uses, and merely wish to point out in what manner it may profitably be employed in dealing with those cases of compound fracture in which the brain has been penetrated.

Firstly, it may be made use of to diminish the intracranial pressure in the stage of traumatic œdema when there is any tendency to the formation of a cerebral hernia, and whilst waiting for the sealing off of the subarachnoid space, which, as has been already explained, renders operation more safe. If employed during this stage, it must be done with great caution, as certain definite dangers attend the removal of too large a quantity of cerebrospinal fluid. The formation of adhesions between the torn dura and the adjacent pia-arachnoid, and the shutting off of the subarachnoid space thereby, is assisted by the pressure of the swollen brain against the edges of the wound. Within limits, therefore, the increased intracranial pressure serves a useful purpose. If by the withdrawal of too much fluid the pressure is reduced to or below the normal, the brain tends to fall away from the dura mater, thus tearing the adhesions and opening up the subarachnoid space to the entrance of infection.

In the second place, lumbar puncture is made use of for controlling any tendency to hernia formation after operation. If the pressure rises so that the tube tends to be extruded, a lumbar puncture should be done; the tube in fact affords a valuable indication as to the degree of intracranial pressure, and therefore as to the advisability of performing lumbar puncture.

We have been employing the apparatus described by Cassidy and Page in the *Proceedings of the Royal Society of Medicine* * in order to measure the cerebrospinal pressure. The reading obtained with this instrument expresses in centimetres the height of a column of physiological saline solution which the intracranial pressure will support, and the normal is taken as about 15 cm. In these cases the reading of course varies greatly, and is often found to be between 40 and 50 cm. In some cases it has been very much higher. According to the pressure in any given case, we allow from four to six drachms of cerebrospinal fluid to escape—into a sterile test tube, in order that it may be examined cytologically and bacteriologically—and then read off the pressure again. If it has fallen to about 20 cm., no more fluid is withdrawn at that sitting; but if the pressure, as indicated by the appearance of the wound, rises again subsequently, the operation is repeated. This procedure may, if necessary, be carried out daily for several consecutive days.

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* Vol. iv, pt. 1, Clin. Sect., p. 56.

TRAUMATIC AND ARTERIO-VENOUS ANEURYSM.

A SECOND SERIES OF CASES—*continued from page* 328.

XII.—AN ANEURYSMAL VARIX OF THE INTERNAL JUGULAR VEIN AND THE INTERNAL CAROTID ARTERY, WITH UNUSUAL CONSEQUENCES.

By Sir JOHN BLAND-SUTTON, LL.D., London.

The remarkable series of traumatic aneurysms published in this Journal (vol. iii., p. 282) makes a valuable contribution to the practical surgery of the vascular system. In common with other surgeons attached to military hospitals, I have had under my care several soldiers with traumatic aneurysms. In dealing with them, many features have arisen to upset my notions in regard to treatment, collateral circulation, recurrent hæmorrhage, and sequelæ. The most remarkable case I have seen is an aneurysmal varix in the neck caused by a bullet, and the patient, a woman. Surgical treatment in this instance has been followed by consequences of such an exceptional character, that it is a duty to record them.

A spinster, age 27, an attendant at a miniature rifle-range, was hit in the left side of the neck by a ·22 short lead rifle-bullet. The rifle was fired accidentally six yards from her. The bullet, after passing through a thin wooden partition, entered the woman's neck near the posterior border of the sternomastoid muscle, on a level with the angle of the jaw. The injury was attended with free bleeding and swelling. Twenty minutes later a doctor plugged the wound in the neck, and within six hours of the receipt of the injury the patient was conveyed to the Cardiff Hospital. On admission, there was much swelling around the wound, and about this time she became conscious of " a loud buzzing in the left ear," which she likened to the rushing noise of an express train. The wound healed quickly and the swelling in the neck gradually subsided, but the noise in her head persisted. This noise caused her so much distress that she sought relief at the Middlesex Hospital, and was admitted under my care, Dec. 3, 1914, seven weeks after the accident.

On the left side of the neck, in line with the angle of the jaw, there was a small red scar, the only visible sign of an injury; but by placing the fingers on the skin in the immediate neighbourhood of this scar, a very distinct systolic thrill could be felt, resembling the buzzing of a fly imprisoned in a paper bag. On auscultation, a loud buzzing systolic sound was heard in any part of the neck: loudest on the left, but distinctly audible on the right side. The thrill could be felt on the inner wall of the pharynx near the tonsil. An *x*-ray examination showed a small flattened bullet, apparently lodged in the prevertebral muscles on the left side about the level of the angle of the

jaw. There could be no doubt that the woman had an aneurysmal varix connected with the internal jugular vein and one of the carotid arteries, probably the internal carotid.

I was uncertain as to the proper course to follow. The woman settled the matter by asking for relief from the persistent roaring noise in her head, which prevented sleep. After careful consideration I decided to deal with it surgically. On Dec. 5 the internal jugular vein was exposed by an incision following the anterior border of the sternomastoid muscle. The vein, greatly dilated in the neighbourhood of the scar, was easily isolated from its sheath, except where it adhered firmly to the internal carotid artery. The common facial vein crossed the field of the operation; convenience and safety required its division between two ligatures. The internal jugular vein was tied above and below the communication. On knotting the upper ligature, the vein collapsed, and the situation of the fistula between it and the artery could be easily seen. For safety, I placed two ligatures on the internal carotid artery, one above and one below the injury to its wall. Briefly, the internal jugular vein and the internal carotid artery were ligatured above and below the perforation, and the common facial vein was tied because it interfered with the manipulations. The skin incision was closed with interrupted sutures; it healed soundly in ten days. Boiled silk was the material used for ligatures and sutures.

In the course of the operation I felt carefully around the wound with the hope of finding the bullet, but failed to discover it; I made no great effort to do so.

The symptoms that followed the operation were carefully observed and recorded by the officers in charge of the patient. The injured vessels were ligatured on Dec. 5, and the patient's condition remained satisfactory until Dec. 10: on that day it was noted that the movements of the right shoulder-joint and elbow-joint were impaired, and that she had lost the power of using the muscles of the forearm and fingers. By Dec. 12 she had lost the use of the right leg, but the knee-jerks were exaggerated. On Dec. 16 slight weakness of the orbicularis oris and the elevators of the upper lip was noticed. There was no loss of sensation in the arm or the leg. On Dec. 31 there was some improvement in the leg, and the patient could shuffle about, but had a paraplegic gait. She remainded in the hospital until Jan. 6, 1915, when she became an out-patient in the neurological department, under Dr. Campbell Thomson, and attended regularly for massage treatment. Her condition improved, and she could walk about, but the right arm did not recover.

In March, 1915, the patient complained of diplopia, and was re admitted to my ward for observation. She had some power in the right leg, and managed to walk about; although unable to use the right arm, she could move the thumb and the index finger. There was well-marked proptosis affecting both eyes. On April 15, Mr. Arnold Lawson reported the existence of papillitis with hæmorrhages and double optic neuritis. Sight was rapidly failing. The symptoms were attributed to intracranial pressure and thrombosis of the cavernous sinus.

Reflecting on the clinical features of this case, I find it difficult to assess the post-operative damage to the nervous tissues. The frequency with which the internal jugular vein is ligatured in operations for the removal of enlarged and infected lymph nodes in the neck of children, and malignant cervical tumours in adults, makes it difficult to attribute the motor paralysis and the thrombosis to ligature of this vein.

I venture to report this case in the hope of extorting from surgeons reports of similar cases. If such serious sequelæ are common after surgical intervention in aneurysmal varix of the jugular vein and carotid artery, they should be recorded, for they may prove that the surgical methods for dealing with such injuries require modification. I am full of hope that the facts here narrated will stimulate surgeons who have had operative experience of aneurysmal varix of the big vessels of the neck to obtain information in regard to the subsequent condition of the patients.

XIII.—TWO CASES FROM THE WHARNCLIFFE WAR HOSPITAL, SHEFFIELD.

Case 1.—Arterio-venous Aneurysm of the Common Femoral Artery.

F. C., age 22, was wounded by a bullet in the upper part of the left thigh at Hooplines on Sept. 4, 1915, and was admitted to the hospital on Sept. 12. There was a healed wound of entrance on the front of the left thigh, immediately on the outer side of the left common femoral artery, and a wound of exit, also healed, at the junction of the upper and middle thirds of the outer surface of the right thigh. The bullet must therefore have taken a curved course across the lower portion of the trunk.

On examination, both thighs were found movable at the hip-joints without pain. In the region of the common femoral vessels was a pulsating red swelling, having the appearance of a cellulitis of that region. On palpation, there was no heat nor tenderness, and there was a marked thrill. The swelling extended for four inches from above downwards, and for three inches across, reaching above to the fold of the groin. The thrill was very marked over the area indicated, and extended laterally in a less degree for half an inch outside this area; it could be felt above in the external iliac artery, and it extended downwards as far as the lower limit of the superficial femoral artery; it could not be felt in the popliteal artery. The posterior tibial pulse was diminished on the left side. On auscultation, the murmur corresponded with the thrill. It was doubtful whether the pulsation was expansile or not. An *x*-ray examination showed some slight roughening along the under border of the left side of the pubic arch, possibly due to trauma by the bullet: there were no clinical signs of damage to the urethra—micturition was painless and of normal frequency.

On Sept. 20 the swelling appeared to have enlarged slightly. The limits of marked thrill were traced on the skin with indelible ink, and six days later it was found that this thrill had extended laterally for about half an inch beyond the skin markings. *Slight* expansile pulsation could be made out by means of two pins piercing a piece of strapping and applied to the skin over the tumour.

Operation, Sept. 27.—A curved incision with its convexity inwards was made to the inner side of the swelling, and the vessels were exposed, lying embedded in scar tissue, by turning a flap outwards. It was intended to deal with the condition by Matas' method; but on attempting to dissect out the vessels further, there was a burst of hæmorrhage which made the carrying out of this project impossible. Attempts were made to pick up the bleeding point by pressure forceps, and to ligature, proceedings which resulted in increased hæmorrhage; the bleeding was both arterial and venous. The hæmorrhage was controlled by a second assistant, and through a small incision in the left rectus sheath, the left common iliac artery was exposed and temporarily occluded by a ligature passed beneath it and drawing it up towards the abdominal incision. This was found to control the arterial bleeding absolutely, but that from the vein was still severe. A tourniquet placed round the middle of the thigh diminished the bleeding. Owing to the great loss of blood and length of the operation, the condition of the patient was bad. The opening in the sac of the vessel could now be seen, and was caught up by a large Spencer Wells' forceps, the common femoral artery was exposed and ligatured immediately above and below the swelling, the wound was packed and partially closed, and the patient returned to bed. Seven hours later death occurred from collapse, in spite of saline infusion, pituitary extract, etc.

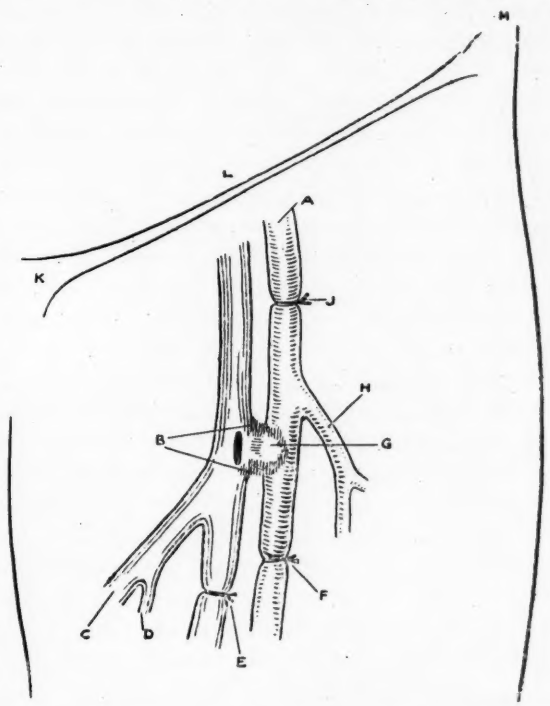


Fig. 160.—Arterio-venous Aneurysm of the Common Femoral Artery.

The circular aperture was $\frac{3}{16}$ in. in diameter, and had smooth, rounded, and thickened edges, *very pale pink* in colour. Firmly adherent to these edges, and connecting the artery and vein, was a fibrous track, with a smooth internal surface. A. Femoral artery; F. Firm cicatricial tissue; C. Internal saphenous vein; D. Deep circumflex vein; E. Distal ligature on femoral vein; F. Lower arterial ligature; G. Localized inflammatory patch, not involving entire lumen; H. Profunda artery of large size; J. Upper arterial ligature; K. Pubes; L. Poupart's ligament; M. Anterior superior iliac spine.

At the autopsy, an arterio-venous aneurysm imbedded in recently formed scar tissue was found. *Fig.* 160, from a sketch by Capt. R. E. Humphry, R.A.M.C. (T.), shows the condition present.—[*Ref. No.* 100.]

Case 2.—**Rupture of Arterio-venous Aneurysm of the Axillary Vessels.**

D. L., age 27, was wounded at Vermeilles, Sept. 28, 1915, by a rifle bullet which passed through the left shoulder, the entry wound being in front, half an inch above the axillary fold, and the exit wound on the inner and posterior

surface of the arm, just above the junction of the upper and middle thirds. He was admitted to the hospital on Oct. 1.

Operation, Oct. 8.—This was an emergency operation undertaken as a result of sharp secondary hæmorrhage. Under ether anæsthesia a longitudinal incision four inches long was made just in front of the wound of exit. On examining the wound no hæmorrhage was at first discovered; but on gently exploring it more deeply, the point of the finger could distinctly feel a hole in a muscle, and a soft material—evidently blood-clot—which filled up the hole. On passing the finger through this hole it at once came into a cavity beyond, also full of blood-clot, and on withdrawing the finger there was a very formidable gush of arterial blood. It was evident that the main artery was ruptured. Having controlled the hæmorrhage by digital pressure in the axilla, further exploration was at first attempted; but it became manifest that this was and would be futile. An oblique incision was therefore made below the left clavicle, the inner edge of the pectoralis minor was defined, and the first part of the axillary artery and the cords of the brachial plexus were brought into view in the bottom of the wound. The operation presented unusual difficulties, as the hand controlling the hæmorrhage had to be kept in the axilla, and the arm abducted. A double ligature was now passed round the subclavian artery immediately under the clavicle, and tied. The cephalic vein was in the way of this operation, and had to be ligatured and divided; its size was unusually large. The wound was now closed and sutured.

On returning to explore the bullet wound again, a very considerable hæmorrhage was still present, and although not very dark in colour, it was certain that it must be venous. With further dissection the axillary vein was isolated, and a marked aneurysmal dilatation was discovered, from a hole in which the bleeding was taking place. The axillary vein was now ligatured above and below the dilatation, a small drainage tube inserted, and the wound closed.

This was a case of ruptured arterio-venous aneurysm; but no thrill could be felt before the operation was commenced.—[*Ref. No.* 101.]

XIV.—NOTE ON ARTERIAL WOUNDS, WITH FOUR CASES FROM THE 17th GENERAL HOSPITAL.

By F. C. PYBUS, Newcastle.

During a period of some months in charge of the surgical division of the hospital, I had an opportunity of seeing a number of arterial wounds received in action in Gallipoli. While at present in England on leave, I have no detailed notes of the cases, so my contribution must be largely of the nature of general impressions. I can recall to memory at least eight cases of arterial injury, exclusive of secondary hæmorrhage.

Cause of Wound.—Most of these cases were the result of injury by rifle bullet. The Turkish bullet is similar to that used by the Germans. I have compared those removed from our soldiers returned from France and those removed during the Dardanelles Campaign.

Types of Injury.—(1) Complete or partial division of an artery, with an open wound, resulting in primary hæmorrhage; (2) Wounds of an adjacent artery and vein, resulting in aneurysmal varix; (3) Wounds of an artery, the resulting wound being plugged with the nose of the bullet (*Case* 4); (4) False aneurysm, consisting of a damaged artery communicating with a sac of varying size; (5) Secondary hæmorrhage, which was by no means uncommon after wounds or amputations, due to the grossly septic state of the wounds when they reached the base.

Arteries involved in False Aneurysm. — Radial and interosseous, 1; axillary, 2; posterior tibial, 1; popliteal, 2; femoral, 2.

Signs of False Aneurysm.—(1) Bullet wound, with retention of bullet or with both entrance and exit wounds; at some part the track passes near one of the large arterial trunks. (2) Swelling, localized or diffuse, at first hard, later becoming softer as the swelling increases. (3) Pulsation, expansile in type. (4) Discoloration. There may be, and usually is, considerable staining of the skin, resembling the ecchymosis associated with a fracture. (5) Leaking. In some cases, where the wound is unhealed, leaking occurs, either a mere oozing which gradually stains the dressing, or a sharp hæmorrhage. (6) Bruit.

The signs of false aneurysm were usually well marked within a week.

The methods of treatment at one's command are: (1) Proximal ligature; (2) Exploration at the site of the injury, through the aneurysmal sac.

My own practice consisted of exposure of the wounded artery and ligature through the sac, after obtaining control of the main vessel of the part (*Case* 1). Experience has justified the belief that this is the right principle. I have seen other methods used and quote instances.

1. *Proximal Ligature.*—The one advantage of simple proximal ligature is that it is easy, and may be done in an emergency without assistance. Its disadvantages are well known: (*a*) It may not stop the pulsation; (*b*) Pulsation may return after being stopped temporarily; (*c*) It is frequently difficult to judge the exact artery damaged, and a main trunk may be occluded for injury of one of its smaller branches.

2. *Ligation at the Site of Injury.*—This method has the following advantages: (*a*) It makes certain of the damaged vessel itself being ligatured; (*b*) Any damage to the corresponding vein may be dealt with; (*c*) The damaged vessel, if a main trunk, may be repaired without occlusion in some cases. The ideal operation is difficult and may be prolonged. It consists in (1) Controlling any possible hæmorrhage by means of a tourniquet, or by exposing the main vessel on the proximal side and applying a temporary ligature or clamp; (2) Opening the sac by a sufficiently long incision and turning out its contents; (3) Finding the damaged vessel, which is dealt with by ligature or suture.

It may be necessary to relax the tourniquet or clamp in order to find the point of damage—by allowing the vessel to bleed. In all cases this procedure should be carried out before the wound is closed, so as to ensure the vessel being adequately dealt with and to reveal any other injury; these may be multiple, as in *Case* 1 recorded below.

The wound may be closed completely, or a small drain may be inserted for twenty-four hours. At the same sitting the bullet may be extracted.

Case 1.—**Aneurysm of Forearm. Damage of Radial and Interosseous Arteries.**

Patient wounded through the forearm. Wound of entry in centre of the outer border of the forearm. Bullet could be felt under the skin, near the internal condyle of the humerus. A pulsating swelling appeared on the upper part of the front of the forearm and antecubital space within a week. There was a definite bruit, and a constant leaking from the wound of entry.

Operation.—A tourniquet was applied to the arm. An incision was made over the sac, in the length of the forearm. The sac was opened and the clot evacuated. After a careful search the interosseous artery was found divided. A ligature was applied to the cut end. On relaxing the tourniquet, there was a sharp hæmorrhage from the distal part of the sac, and the radial artery was found divided. Both ends were ligatured, and this finally stopped the bleeding. The wound was now closed except for a small drain. The bullet was removed through a small separate incision. The patient did well, the wound healed per primam, and he was discharged in ten days. The track of the bullet crossed both the radial and interosseous arteries, damaging both.

Case 2.—**Axillary Aneurysm.**

Patient shot through the anterior fold of the axilla. Exit wound through the posterior wall of same. Bulging and pulsation of the floor and anterior wall of the axilla.

Operation.—(1) Proximal ligature of the third part of the subclavian artery; (2) Exposure and ligation of the brachial artery just below the axilla; (3) Sac opened, hæmorrhage still quite free. Careful search demonstrated that the subscapular artery had been damaged, and ligature of this vessel at once stopped the bleeding.

This case well illustrates the need for treatment, as in the former case, by temporary control only of the main trunk. In spite of ligatures, both proximal and distal, the scapular anastomosis was sufficient to maintain free hæmorrhage from the subscapular artery. This patient did well.

Case 3.—**Bullet Wound of the Lower Third of the Thigh.**

No exit wound. The direction of the bullet suggested that it must have damaged the upper part of the popliteal artery.

Case seen ten days after injury. The whole of the leg and lower third of the thigh were swollen. There was marked ecchymosis from the thigh to below the ankle. This at once suggested aneurysm, and on palpation I found the whole popliteal space, calf, and leg pulsating, as far as the ankle. For this the femoral artery was ligatured in Hunter's canal. This measure stopped the pulsation for some days at least—as long as I was able to watch the case.

Case 4.—**Wound of the External Carotid Artery.**

Patient shot in the neck. The bullet could be easily felt in the upper third of the neck, at the anterior border of the sternomastoid muscle. There were no signs of any arterial injury.

Operation.—Under general anæsthesia an incision was made over the bullet, which was extracted. This was immediately followed by a profuse hæmorrhage. The wound was enlarged, and an opening found in the external carotid artery—which the nose of the bullet had occluded. The artery was ligatured.

ILLUSTRATIONS OF WAR SURGERY.

(*Continued from page* 275.)

[Under this heading we propose to publish during the War a series of drawings illustrative of military surgery in its various aspects. The BRITISH JOURNAL OF SURGERY is indebted to Surg.-Gen. Sir George H. Makins for his help in the selection of cases and for his clinical remarks on certain of those selected. The notes, supplied by various officers of the Royal Army Medical Corps under great pressure of work, are necessarily brief. The drawings have been made by Mr. A. K. Maxwell.]

Wound of the Left Scapular Region caused by a Fragment of a High-explosive Shell (*Fig.* 161). (From No. 13 General Hospital, Boulogne. Under the care of CAPT. OLIVER.)

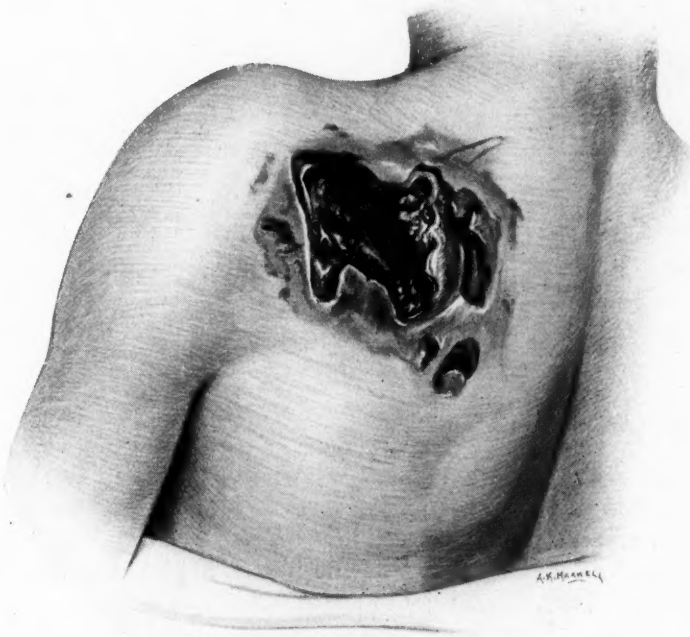


FIG. 161.—SHELL WOUND OF SCAPULAR REGION.

The drawing was made about ten days after infliction of the injury. On admission the wound was much inflamed, and a large area of skin around was red and œdematous. It was laid freely open and drained, and the illustration shows it in the stage of repair. [*Ref. No.* 22.]

Gaseous Cellulitis of the Thigh, with large Subcutaneous Gas Bubbles. (From No. 7 Stationary Hospital, Boulogne. Under the care of CAPT. MARTIN.)

The patient was admitted with multiple flesh wounds caused by shell fragments, chiefly involving the left thigh and arm.

He showed the usual signs of severe general infection by anaerobes and streptococci—yellow skin, a small rapid pulse of low tension, and no great rise of temperature. He died four days after the reception of the injury.

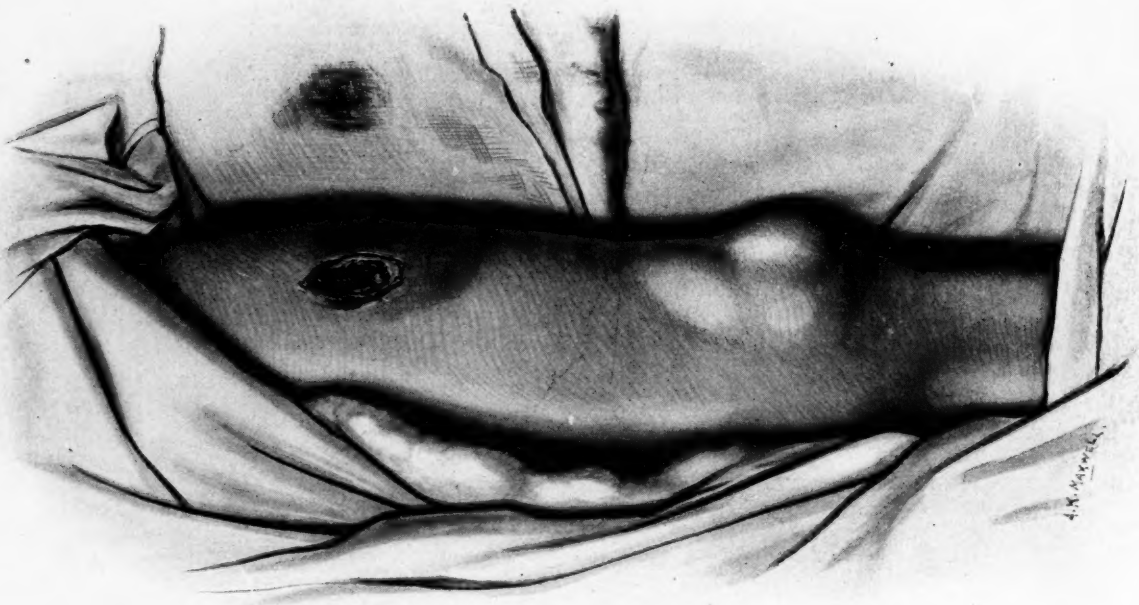


FIG. 162.—GASEOUS CELLULITIS.
Very large subcutaneous bubbles. Wound caused by shell fragment.

The wound illustrated (*Fig.* 162) was drawn the day before death, at which time an area of chocolate-brown skin extended down towards the knee. Over this area emphysematous crackling could be felt, and traced to the several large bubbles of gas, shown in the illustration, which raised the skin round the patella. [*Ref. No.* 28.]

T-shaped Fracture of the Lower End of the Right Femur. (From No. 7 Stationary Hospital, Boulogne. Under the care of CAPT. MARTIN.)

The wound was caused by a fragment of shell entering at the lower part of the front and inner aspect of the thigh, just above the knee-joint. The wound was cleansed, a tube was inserted into the joint, and the limb put up on a long Liston's splint under an anæsthetic at the casualty clearing station.

Two days later the patient arrived at the base hospital. His general

condition was good, but the wound was in a septic condition. An *x*-ray examination revealed the injury shown in *Fig.* 163 (a very beautiful illustration of the mechanism of production of a T-shaped fracture), and amputation was decided upon. After removal, the joint was found to contain a foul chocolate-coloured fluid and fragments of clothing. The fracture was unaccompanied

FIG. 163.—FRACTURE OF THE FEMUR BY A FRAGMENT OF SHELL.

by laceration of the posterior muscles, and the popliteal vessels were intact. A notable clinical feature was the broadening of the knee owing to the spreading apart of the condyles by the wedge-shaped lower end of the femoral shaft. The amputation was carried through the lower third of the thigh; the flaps were left open, and granulated well. The patient was sent to England, and died a fortnight later of enteric fever. [*Ref. No.* 30.]

Gaseous Cellulitis. Bullet Wound of the Right Leg and Comminuted Fracture of the Tibia and Fibula. (From No. 13 Stationary Hospital, Boulogne. Under the care of Lt.-Col. Butler.)

The entrance wound was situated in the lower third of the back of the leg.

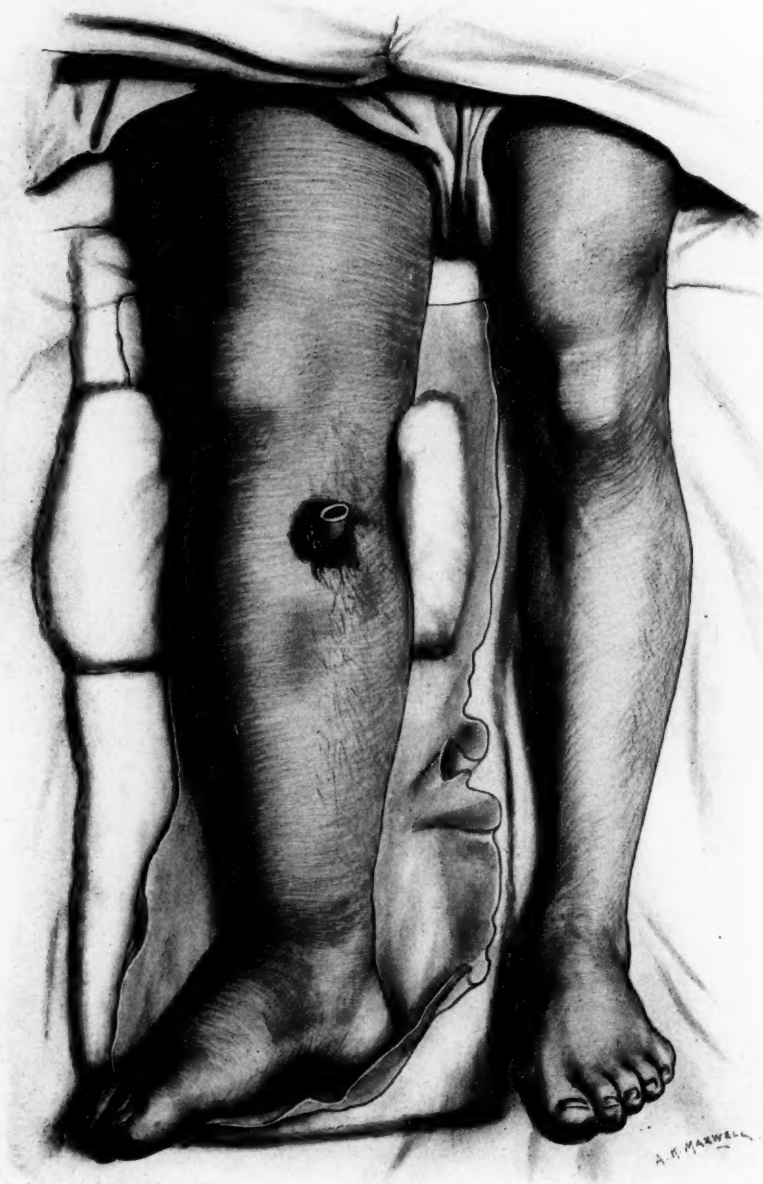


Fig. 164.—Gaseous Cellulitis of Leg.

When seen on the third day the limb was swollen, as depicted in the drawing, and there was considerable dusky discoloration. Two large blisters were situated on the front of the leg below the exit aperture of the bullet, which latter was irregularly rounded and occupied by a drainage-tube (*Fig.* 164). Foul discharge and bubbles of gas were escaping freely from the wound. The patient's temperature was 100·4°, the pulse 108, and his general condition fairly good.

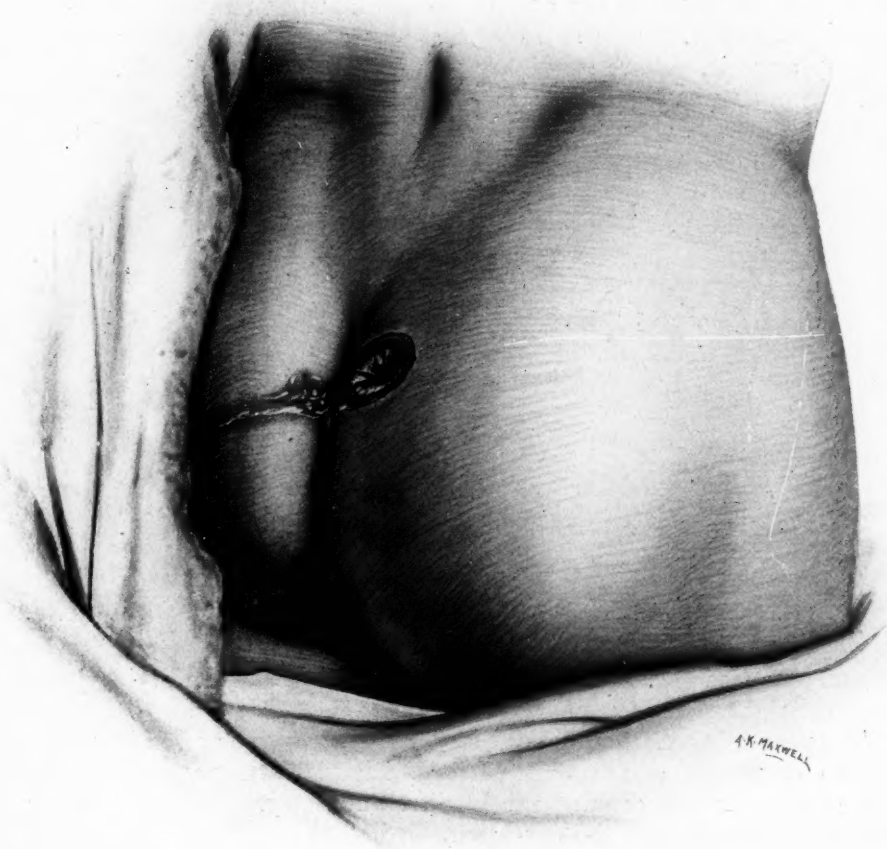


Fig. 165.—Wound of Buttock from Shell Fragments.

On the fifth day both entry and exit wounds were enlarged, the track of the bullet was opened up, cleansed with 5 per cent carbolic acid lotion, and a drainage tube passed through its whole length.

Under the use of boracic fomentations applied every two hours, and daily syringing with carbolic lotion, rapid improvement took place, and on the twentieth day the patient was transferred to England in good condition.—[*Ref. No.* 34.]

Shrapnel-case Wound of the Right Buttock, involving the Rectum and Bladder. (From No. 19 Stationary Hospital, Boulogne. Under the care of Lt.-Col. Butler.)

The drawing (*Fig.* 165) was made from a man suffering from multiple shrapnel wounds of the pelvis, the left forearm, and both legs, of which the pelvic wound was the only serious lesion.

The illustration is of the entrance wound, an irregularly circular aperture in the right buttock, to which leads a graze of the left buttock.

The drawing was made on the third day, up to which time he had passed neither fæces or urine by the normal passages. The man was very restless, in considerable pain, his skin and conjunctiva were of a yellowish tinge, and he was very anæmic. Pulse small and rapid. Temperature 102·8°.

The wound was about the size of a shilling, and passed through the upper part of the sacrum close to the median line. A skiagram showed a piece of

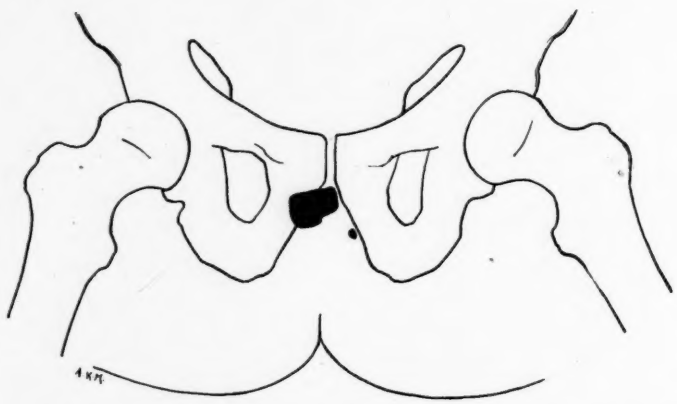


Fig. 166.—An outline of a skiagram of the pelvis of case shown in *Fig.* 165.

shrapnel case (see *Fig.* 166), apparently within the pelvis and lying just below and to the right of the symphysis pubis.

The patient's condition became steadily worse, urine and fæces were escaping from the wound, and on the eighth day Lieut. Townrow performed a suprapubic cystotomy and drained the bladder anteriorly. The fragment of shell was not palpable during the operation.

Immediate improvement followed the operation, and on the fourteenth day little fæces and no urine were escaping from the posterior wound. On the sixteenth day the general condition was sufficiently good to allow of the transference of the patient to England. [*Ref. No.* 35.]

Bomb Wound of the Face. (From No. 13 General Hospital, Boulogne.)

This patient received wounds of the face and both hands.

Taken with *Fig.* 85, together with *Fig.* 37 (*Brit. Jour. of Surg.*, July), this illustration completes a series showing the effect of bomb or shell wounds in the various degrees short of serious loss of substance of the face or

head. Injuries of the 'tattoo' type and minimal wounds of the lips in this instance healed rapidly, and the patient was sent to England on the eighth day. The local swelling of the lips accompanying such small lacerated and contused wounds is well shown.—[G. H. M.] [*Ref. No.* 42.]

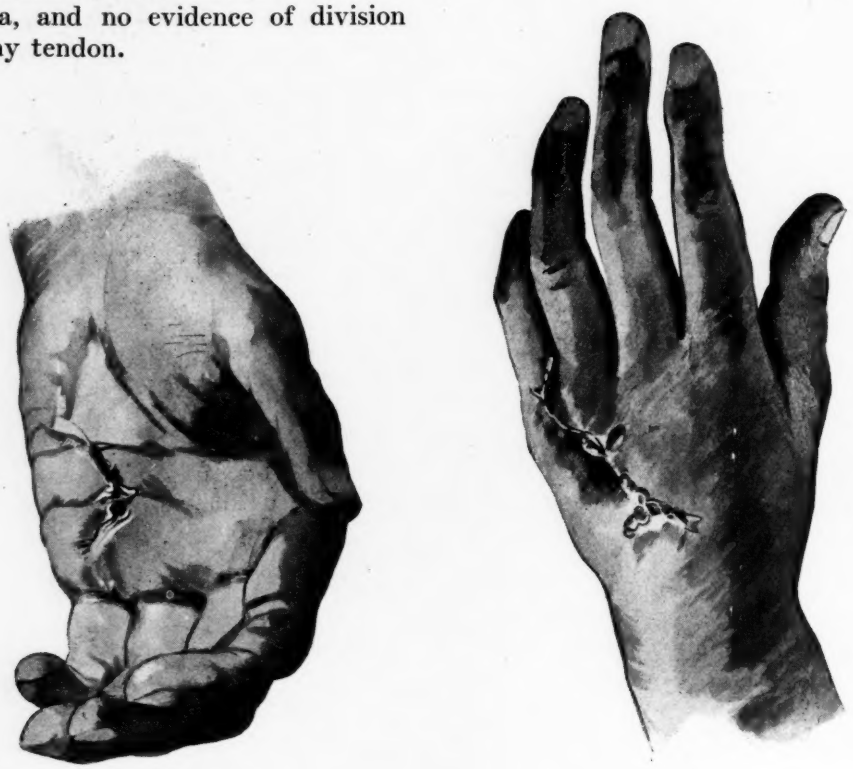
FIG. 167.—BOMB WOUND OF FACE.

Bayonet Wound in the Hand. (From the 3rd London General Hospital, Wandsworth (T.). (Communicated.)

The accompanying sketches (*Figs* 168, 169) indicate the nature of the wound produced by a bayonet thrust through the hand. The patient was wounded on July 7, 1915. His party were digging-in a field gun when they were suddenly attacked by a large body of the enemy. Glancing up

from a stooping position, he found a hostile bayonet almost in his face. The hand which he raised to thrust it aside was transfixed in the manner indicated. The bayonet entered the palm, fractured or cut through the fourth metacarpal, and emerged at the back of the hand. It will be noted that the scar of the exit wound is much larger than that of entrance. This seems to indicate a considerable angular movement of the bayonet after it was introduced. The weapon was not a triangular one, but of the same shape as the English bayonet.

At the time of his admission to the 3rd London General Hospital, on August 24, the wound was practically healed, and the fracture had united. There is some little weakness of the fourth finger, and a loss of prominence of the knuckle; but there is no anæsthesia, and no evidence of division of any tendon.



a *b*

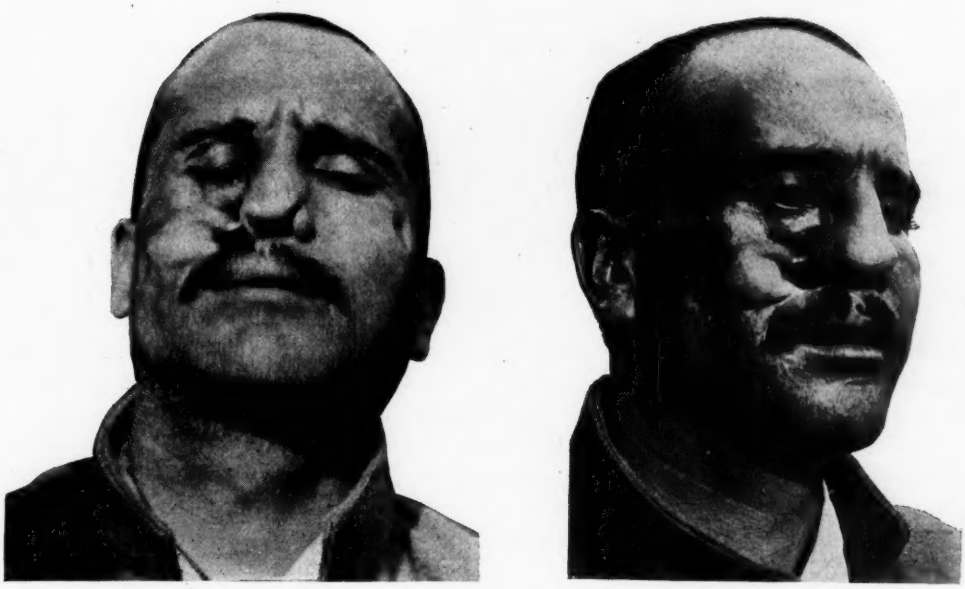
FIGS. 168, 169.—BAYONET WOUND OF HAND.
(*a*) Wound of entry; (*b*) Wound of exit.

The sketches were made by the R.A.M.C. orderly attached to the ward, Private Shewring.

The principal interest of this case lies in the fact that the exit wound, though separated from the wound of entrance only by the thickness of the hand, is more than twice as long. At a distance of five inches from the point of penetration, an angular movement of the same amount would divide the tissues over an extent of more than six inches, sufficient in the thorax to injure nearly all the vital structures. [*Ref. No.* 99.]

Bullet Wound in the Face, with Explosive Effect at the Aperture of Exit. (From the 3rd London General Hospital, Wandsworth.) (Communicated).

On October 26, 1914, at Ypres, this patient was shot through the face by a rifle bullet which entered at the left malar eminence and emerged through the right cheek. The patient was taken prisoner, and two operations were performed upon him, the first by a German, the second a plastic operation



FIGS. 170 171.—WOUND OF THE FACE BY A RIFLE BULLET.

by a French surgeon. The wound of exit is a large gaping one, opening into the right axillary antrum, and communicating freely with the nose.

The case illustrates the pseudo-explosive effect sometimes produced by a pointed rifle bullet. The patient declined further operation, and was discharged from the Army. [*Ref. No.* 98.]

A STUDY OF THE CHANGES MET WITH IN THE LEUCOCYTES IN CERTAIN CASES OF MALIGNANT DISEASE.

By O. C. GRUNER, Leeds.

The clinical value of the study of the blood by means of the stereotyped bedside hæmatological methods is not very conclusive. It is true that considerable assistance may be rendered in deciding between such conditions as intra-abdominal hæmorrhage and fulminating appendicitis or perforated gastric ulcer, as has been shown more recently by Jules Rey.[1] Nevertheless, the range of data is limited when only total cell-counts and differential counts are utilized.

When Arneth introduced his well-known system of classifying the neutrophile leucocytes, he enabled clinical hæmatology to move one step in the right direction. Up to the present, however, this system has not been extended to the other cell types present in the blood-stream.

The writer has made some investigations in this further direction,[2] but discovered an important fallacy underlying the method of study—namely, that the changes met with in a patient are naturally enough correlated with the clinical diagnosis, whereas they should be correlated with the physiological condition of the patient's tissues. The latter appears to be disregarded because the 'disease' claims first attention; not to mention the circumstance that there are no methods of determining the patient's physiology other than by elaborate 'metabolism experiments.' In other words, the really important thing about a patient remains untouched.

I.—THEORETICAL BASIS OF THE STUDY.

Before describing the findings in the blood in cases of malignant disease, it is necessary to bring the suggestion forward that a mere record of facts will not help diagnosis or prognosis, until they are correctly assessed in the light of every possible conception of 'disease.'

We have pointed out before[3] that a blood-count represents the condition of the blood only at the particular moment when it was collected; that certain features may have changed even within an hour's time; that there is no such thing as a disease of the blood; that the changes one meets with can be nothing more than an index of the relative purity or fouling of a moving stream as tested at any given moment.

The same principle holds good for any section of pathology. A disease is not a fixed picture, but consists in a series of phenomena which steadily pass through a cycle of changes, and only truly terminate when the tissues have become restored to their pristine condition. A disease is therefore not

really an *entity* at all. The clinical diagnosis of a case is merely a label affixed for convenience upon a certain phase in the development of a number of chemical or metabolic sequences. In producing a picture, various ingredients go to make up the finished canvas—seascape, landscape, genre-painting, and so forth—*plus* a living agent which we may call 'A.' At any moment the colours may be transposed, and convert what was about to become a seascape into a landscape, and so forth. Similarly (the analogy is not altogether fanciful),* a number of factors exist in a given patient, which under one influence give no clinical result, under others give rise to various predisposing causes, until the superaddition of an agent 'A' (pneumococcus, etc.) allows the production of a finished picture labelled 'pneumonia,' 'mastoid abscess,' 'endocarditis,' and so forth.

If this be correct, and if we had the requisite knowledge, it should be possible to step into the stream, divert the morbid processes along different lines, and convert one preliminary picture into another, or at least divert the current into a channel the termination of which is not death. The present study may be regarded as an attempt to discover a track which leads into that stream.

It was found that the use of a classification of blood-cells into nearly fifty varieties introduced a means of investigation of attractive acuity. The problem is now one of interpretation.

II.—METHOD OF STUDY.

A.—**Technique.**—After having tested many of the recognized methods of blood-examination according to, first, the extent of information supplied by each, and secondly, the ease of adoption as a routine method, it was found that the study of smears would alone suffice for the present purpose. The blood is conveniently collected from the lobule of the ear, and smears are made in the usual way. Three slides are used for each case.

The *staining method* selected is that devised by Pappenheim, the 'panoptic stain.' This is used as follows: Three or four drops of Jenner's stain are placed upon the film, and the slide is immediately protected by a Petri-dish lid. After exactly 3½ minutes, the lid is removed, and an equal number of drops of distilled water are added to the stain already present. In exactly 2 minutes this is drained off, and the film is flooded with a freshly made dilution of Giemsa (1 drop to each c.c. of distilled water, with 1 drop of 1 per cent potassium carbonate). This stain may be rinsed off with distilled water in not less than 12 minutes; 15 minutes is a convenient routine time. It is almost impossible to overstain. The slide is now rapidly blotted, left to dry in the air, and examined with the oil-immersion without the intervention of a cover-glass.

B.—**Classification of Cells.**—A very detailed classification was adopted, in order to enable the really important types to be selected more promptly than if individual experiments were tried upon successive series of cases. It

* This is a provisional description of an idea which can be adequately represented only by a mathematical formula.

was found unnecessary to carry out actual *total* counts, because the grades of leucocytosis that really signify can be detected in the smear itself.

The following points proved to be of special interest :—

In the neutrophile leucocytes—

Ratio between juvenile and adult forms
Ratio of living to dead forms
Presence of 'bizarre' forms (see *Plate I*)
Presence of nuclear excrescences ('nuclear pseudopods')
Evidence of active amœboid motion
(Spiral lines in the cytoplasm; tigroid and 'leopard' marking in the nucleus; presence of nucleoli).

In the lymphocytes—

Ratio between juvenile and adult forms
Ratio of living to dead forms

Description of Plate I.—Blood-cells in Carcinoma and Sarcoma.

The cells figured are selected from different cases of malignant disease.

The main characters of the neutrophile leucocyte, as shown in *Cells* 1–10, 13, lie in an amblychromatism of the nucleus. The outline is clear, but the nuclear substance is pale, and nucleolar bodies frequently occur within (1, 2, 3, 6, 8, 9, 13.)

The nuclear outline tends to tail off into slender processes which give the outline a bizarre form. Pyriform excrescences are well shown in 6. The ring form in 10 is frequent in carcinoma.

The last three rows, as well as *Cell* 11, represent mononuclear cells of different kinds. The most striking feature is the frequency of amitosis in the circulating cells (16, 17, 21, 23); 17 shows a characteristic unequal division of the nucleus. This is seen to a less marked degree in 23.

14 and 15 show two lymphocytes whose cytoplasm is fixed in an amœboid position.

18 is a large mononuclear leucocyte of irregular form; its nuclear outline is blurred from the formation of successive overflow layers. This feature has been seen in cases of sarcoma. 19 is a similar cell except that the overflow effect covers a larger area than the actual nucleus. 20 is a cell whose cytoplasm is continuous with a polymorphous platelet mass, indicating some definite relation between the two. 21 shows three collections of azurophile granules proceeding from the nucleus, and evidently about to be discharged from the cell.

22 shows an amœboid lymphocyte with a spiral body ('spirilloid'), partly placed within a vacuole.

23 is a leucocytoid monocyte undergoing unequal amitotic division.

11 shows a large hyaline cell whose cytoplasm contains many vacuoles, in which are bright azur-red diploid bodies.

Evidence of amœboid activity
Presence of azur granules
Presence of azur rods or spirilloids.

In the large mononuclear cells (*'monocytes'*)—

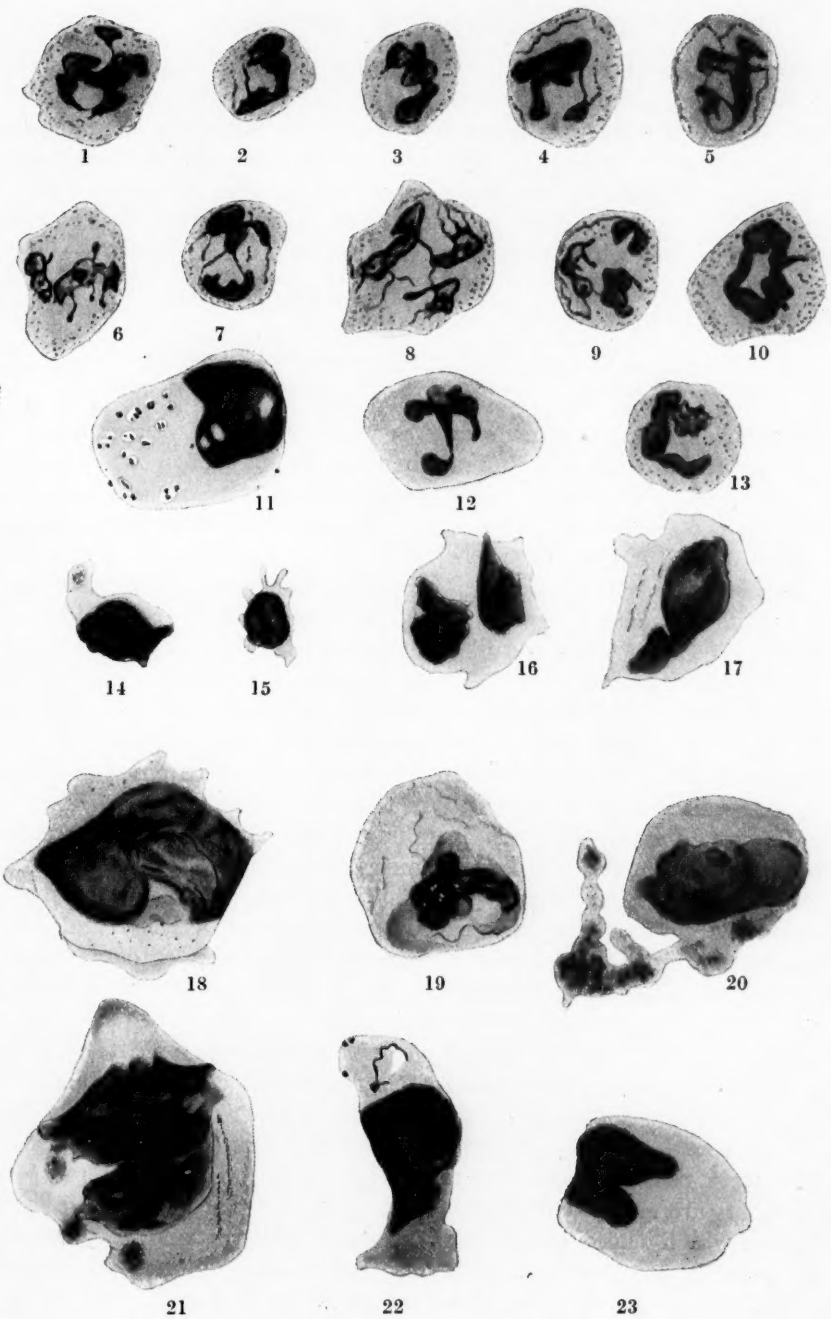
Ratio of amitosing to resting forms
Evidence of amœboid movement in the nucleus (see *Plate II*)
Existence of fatty degeneration
Intranuclear markings, simulating spirilloids
Presence of azur bodies

The so-called hyaline cells, and the micro-monocytes, are included under the heading of monocytes.

New Cells.—A systematic search has been made with a view to discovering points which might distinguish the existence of tumour cells in the films, especially in the case of sarcoma. In one instance a cell was detected which was regarded as a columnar carcinoma cell, and a diagnosis based thereon was substantiated by the subsequent operation. Sarcoma cells are so easily

PLATE I.

BLOOD-CELLS IN CARCINOMA AND SARCOMA



mistaken for lymphocytes in a tissue that it seems possible that they have hitherto been counted among the lymphocytes in the course of a differential count, falsely contributing to the 'lymphocytosis' of some cases of sarcomatosis.

III.—DESCRIPTION OF THE CELLS.

1. **Neutrophile Leucocytes.**—According to the Arneth system, the nuclear forms vary according to the age of the cell. A subdivision of the neutrophiles into five groups according to nuclear form has been extensively used. In the present series, the cells are divided into only two groups. The second group comprises all neutrophiles whose nucleus is actually or almost divided into distinct segments. The first includes Classes I–III as specified by Cooke.[4] The following diagram indicates the nuclear forms :—

I.	II.	III.	IV.	V. Completely partite and dead cells
Juvenile			Adult	

i. *Dead Leucocytes.*—All neutrophiles which show defective nuclear staining are regarded as dead cells. A distinction can be drawn into 'dying' and 'dead,' but though recorded in the actual cell counts, it is not referred to specifically in the results appended here. The characteristic form and colouring of these cells is shown on *Plate IV*.

ii. *Ratios.*—These may be expressed in actual counts as percentages of the total white cell-count, or they may be corrected to a percentage of the neutrophiles alone, or they may be given in a ratio where the number of juveniles is taken as unity, or the total of adults is taken as unity. In the tables appended the third method has been adopted. As a matter of fact the ratio does not appear to have very great significance. *Table I* shows that the variation is from 1 : 1·1 up to 1 : 6 in the case of carcinoma. *Table II* shows a variation from 1 : 1·2 to 1 : 8 in the case of sarcoma.

iii. *Bizarre Forms.*—By this term is meant the occurrence of a very irregular contour to the nucleus. Fantastic outlines are often produced, resembling various animal forms—insects (imagined as wingless), caterpillars, rabbits, etc. (*Plate I*). The bizarrerie is partly produced by erratic nuclear excrescences, and is a very common feature of the films of cancerous blood. It is not absent in some other diseases, but is inconspicuous, if not altogether absent, in the fasting, healthy subject.

iv. *Nuclear Excrescences.*—Much attention has been paid to this feature, because of the frequency with which it is noticed in certain diseases. These excrescences are classifiable into three forms : (*a*) pyriform in shape, (*b*) blunt and more or less sessile, (*c*) spiculated. The first-named are the most noticeable, but are not necessarily the most significant. In the tables presented, all three forms are shown collectively. In *Table I* we see that there are many instances in which these pseudopods appear. Where present, they are met with in from 2 to 58·5 out of every 100 neutrophiles. Although they are not so frequent in the simple horseshoe-nucleate forms, they cannot be easily referred to as dependent upon the age of the cell. A comparison of

Table I.—Showing the Frequency of the Changes in the Leucccytes in Cases of Carcinoma.

No. of Case	Region	Neutrophiles			Lymphocytes		Monocytes					Remarks
		Ratio of young to old	Percentage of neutrophiles:-		Excess over 20 per cent	Percentage of cells showing amœboid activity	Excess over 10 per cent	Percentage of cells showing				
			Dead	With pseudopods				Amitosis	Fatty change	Bizarre nuclei	Death	
370	Rodent	1 : 3·7	25	18	+	3·8	+	0	0	0	13	
555	Jaw	1 : 1.1	9·2	2	++	6·5	+	0	0	0	23	
485	Cheek	1 : 1·5	1·6	16·6	+	4	+	0	0	0	0	Recurrent
681	Cheek	1 : 1·7	7·7	20	+	0	+	0	0	0	54	
293	Tongue	1 : 6	7·7	4	—	46	++	0	11·6	15	31	
420	Palate	1 : 2·1	0	3	—	10	+	12·5	12·5	6·2	0	
454	Palate	1 : 8	16	13	+	0	+++	0	5·7	0	20	
325	Stomach	1 : 5·6	7·8	0	0	0	0	0	0	20	20	Inoperable
328	Stomach	1 : 3·4	0	0	+	11·6	0	0	0	55	0	Inoperable
563	Stomach	1 : 3·3	2·3	24	—	2	—	1	0	10	1	Secondaries in liver
747	Pylorus	1 : 2·3	5·7	22	—	0	—	0	0	0	0	A small growth but inoperable: general condition bad
369	Sigmoid	1 : 1·7	0	23	—	0	—	0	0	0	0	
381	Sigmoid	1 : 2·7	13	35	+	4	0	30	0	0	0	
320	Sigmoid	1 : 1·9	22·6	10	0	50	0	0	0	0	0	
317	Sigmoid (P.M.)	1 : 2·6	39	0	+++	4	+	0	0	0	39	
380	Transverse colon	1 : 2·2	0	0	+	4·3	+	7·1	0	7·1	0	
349	Rectum	1 : 6·1	1·2	0	—	16·6	—	0	0	12·5	0	Columnar cell found
463	Rectum	1 : 1·9	13	0	—	0	—	0	0	0	0	Very fibrous small growth
323	Rectum	1 : 2·3	8	0	++	2	0	0	0	0	22	
487	Generalized	1 : 1·6	7	23	—	0	+	7	7	5	1	
358	Abdominal (peritoneal dissemination)	1 : 3·3	6·5	0	++	33	—	0	0	0	0	Inoperable
300	Breast	1 : 5	73	0	+	58·5	+	8	0	24	32	Inoperable
303	Breast	1 : 4	35	0	—	0	0	0	0	30	10	Recurrent
296	Breast 7 days after excision	1 : 2·1	4·3	5·8	+	25	0	0	0	0	0	
551	Breast 14 days after excision	1 : 3·8	7	17·6	0	12·5	+	7·1	0	0	28	
470	Uterus	1 : 1·8	4·7	3·5	0	0	0	14	0	0	0	
484	Uterus	1 : 1·3	10	15	++	2·9	+	0	7·9	25	44	

+ means an excess up to 5; ++ means an excess up to 10; +++ means an excess up to 15.

the first and third column shows that there is no numerical relation between the excess of old neutrophiles over young, and the number of pseudopods per hundred neutrophiles.

Regarding these appearances as definitely due to nitrogenous metabolism, one would anticipate that they would be either absent, or at any rate less marked, in those cases of carcinoma where the tumour was so circumscribed by fibrous tissue that cancerous excreta might not enter the blood-stream. An objection to this line of reasoning might lie in the possibility that a tight stricture of the intestine, for instance, leading to chronic obstruction, might be associated with the absorption from the stagnant intestinal contents of toxic bodies of a similar group to the cancerous toxins; such bodies circulating in the blood would equally influence the neutrophile morphology. Two instances in which the neoplasm was circumscribed in the manner indicated are found in *Cases* 747 and 463. The former tumour was, however, not scirrhoid.

Description of Plate II.—Mononuclear Leucocytes in Carcinoma and Sarcoma.

The central portion of the figure shows a collection of cells all taken from the same blood-film—a case of epithelioma. They are grouped together to show how conspicuous the amœboid outline of the small cells is, and the peculiar bizarre character of the other cells.

1–12 present different forms of large mononuclear leucocytes with bizarre forms of nuclei; 1, 3, 5, 6, 7 are from breast cancer. 8 is a dying cell (change of reaction of cell-body as well as of nucleus). 13 has a trifid nucleus. 14 shows a closely coiled nucleus. 15 shows overflow of substance from the nucleus into the cell-substance. An azurophile diploid lies in a vacuole within it. 17 is a micromonocyte with overflow of material in a similar way. Nucleoli are conspicuous. 18 is an aberrant amitosis from a case of mediastinal sarcoma. 19 is a cell taken to be a columnar carcinoma cell. 25, 26, 34, 35 are from one case of sigmoid cancer, showing peculiar forms of lymphocyte-like cell. Note the azur bodies within. 27 is a leucocytoid hyaline cell with azur diploids from a case of gastric cancer. 28 shows a blood-platelet with included spirilloid.

36 shows beaded linear azur lines; 37, 42, 43 show abnormal nuclear outlines. 38, 45, 52 show various forms of amitotic division. 44, 46, 47, 48, 49, 50, 51 show marked lobation of the nucleus giving rise to the appearance of amœboid movement in the nucleus, or irregular budding.

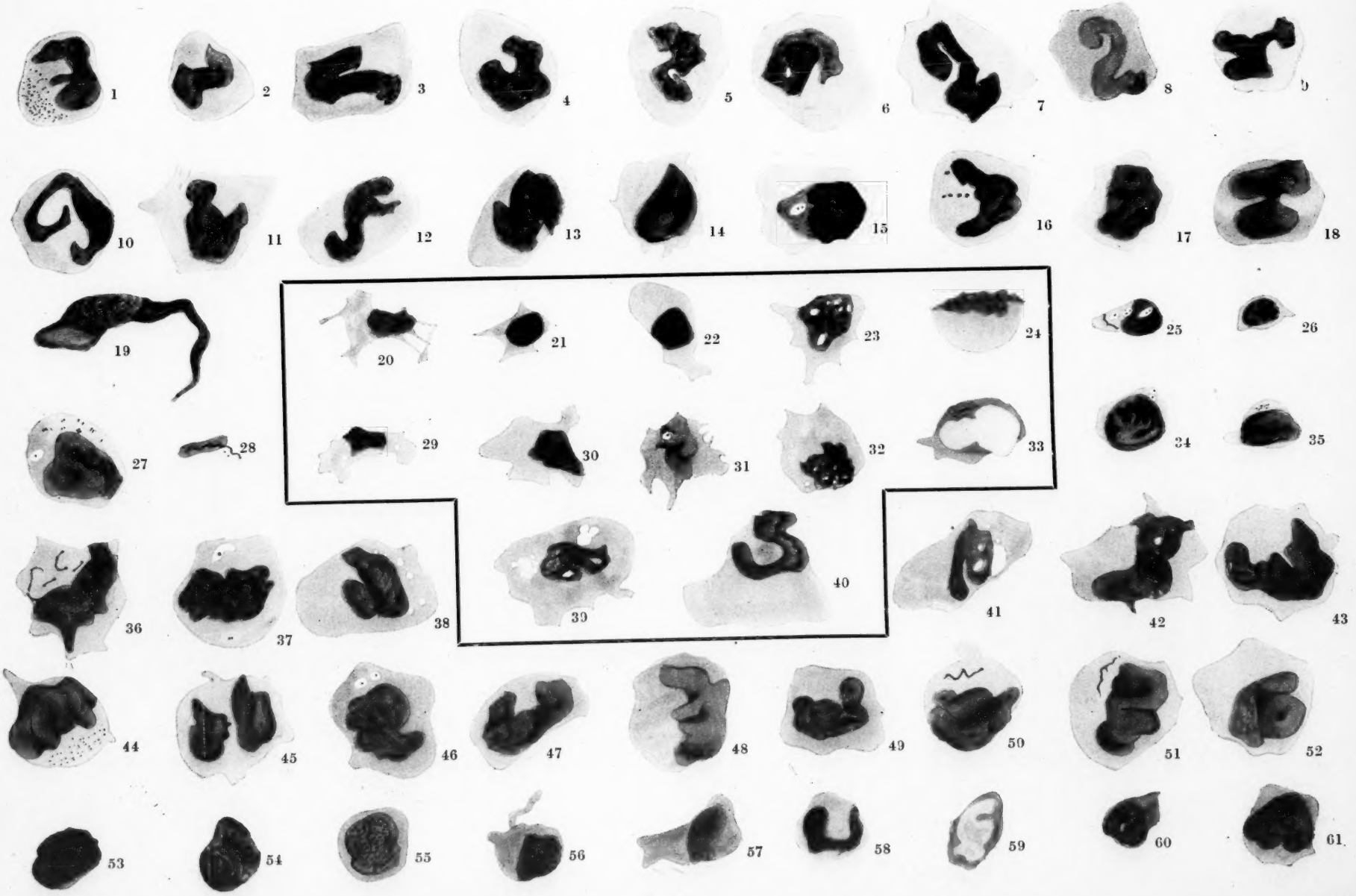
38, 41 show fatty granules in the leucocytes. Small fat-droplets are also seen in 42, 43, 45.

The last row shows various forms of cell regarded as sarcomatous. Their different staining power, and the nuclear markings, indicate a distinct difference from natural blood-cells. 55, 56, 58 show finely granular nuclei.

56 shows a platelet which appears to have fused with the cytoplasm (not an infrequent occurrence). 57 is amœboid in outline.

Influence of Diet upon the Neutrophile Leucocyte.—The fact that the nuclear pseudopods stain like nuclear matter, suggests that they represent an overflow of nuclein bodies into the cell substance. If so, they should be more numerous after certain articles of food have been taken in. In this case the appearance of these structures might be due to the patient's diet, and not to his neoplasm. The matter was therefore tested as follows: The writer commenced using a strictly purin-free diet, allowed some weeks to elapse before regarding the blood as standard, and then partook of isolated and sufficiently heavy purin-containing meals, immediately relapsing to the purin-free dietary for a further period of time. The blood was examined hourly, full differential counts were made on the lines of this study, and control analyses of the urine were made in order to ascertain when the nitrogenous material had actually passed round the circulation. The results were of considerable interest, showing as they do that *it is possible to trace this food material in the blood-stream.* It was found, in other words, that one can reproduce the blood

PLATE II.—MONONUCLEAR LEUCOCYTES IN CARCINOMA AND SARCOMA



picture of carcinoma, in respect to the nuclear pseudopods, by partaking of certain articles of food—notably pork, and, to a less extent, other red meats. The change did not appear in the urine until the altered morphology had already been established.

In *Fig.* 172 we see the effect of (*a*) animal fat, (*b*) pork, upon the blood-cells. In each case the 'meal' consisted solely of the article of diet in question. The rise in the number of the juvenile leucocytes is well shown in (*b*), and the increased numbers of pseudopods is clearly shown. After the diet (*a*), on the other hand, there is a fall of both juvenile leucocytes and of the number of pseudopods. Fat requires the interaction of lymphocytes for its disposal, nitrogenous matter requires neutrophiles. Similarly, following a 'meal' of nothing but boiled cabbage (*c*), we find the pseudopods steadily diminish.

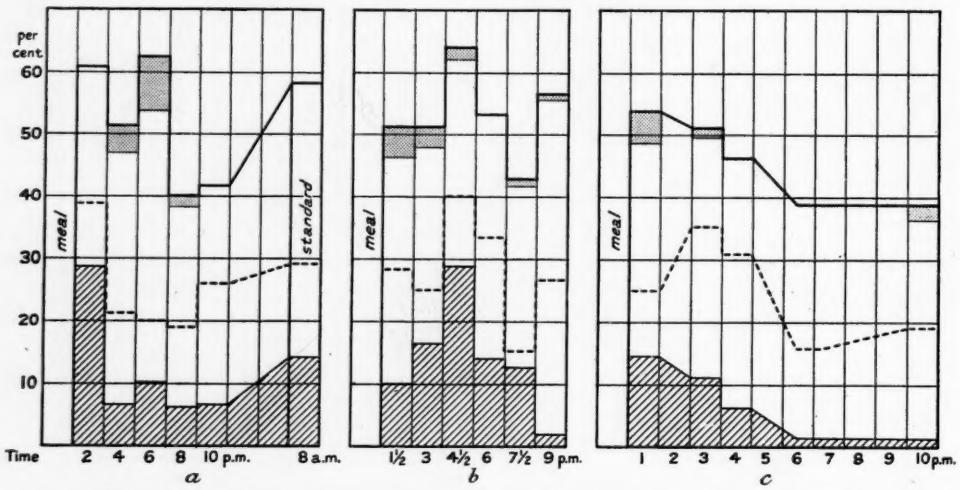


FIG. 172.—CHARTS REPRESENTING THE HOURLY CHANGES IN THE LEUCOCYTE FORMS DURING THREE EXPERIMENTS WITH DIETARY. The standard value is that found in the early morning, the diet being continuously of the strict purin-free material mentioned in the text.

In each chart the complete columns represent the total percentage of neutrophiles; the middle broken line indicates the percentage of juvenile neutrophiles, and the shaded columns the percentage of neutrophiles which contain pseudopods. The dotted areas at the top represent the number of dead or dying neutrophiles per cent of total leucocytes.

a. Changes sequent upon a meal composed entirely of suet (pudding); *b*. Ditto, composed of pork (with gravy); *c*. Ditto, composed solely of boiled cabbage.

In all the cell-counts made in cases of cancer, the mid-day hour was chosen for the collection of the sample, so that the patient had not partaken of animal food since at least mid-day of the previous day.

Strictly speaking, one would put a case upon purin-free diet for several days before collecting the blood; but as we shall see, there are more important points to study—points which are not interfered with or masked by the use of ordinary diet. On the other hand, a pure vegetarian diet will do the patient no harm, and makes the interpretation of the blood-findings more precise. (By a 'pure' vegetarian diet is signified the use of vegetables cooked in the simplest possible way; the introduction of 'fancy-work' into the vegetarian dietary—sauces, spices, etc.—appears to deprave its value to the level of

purin-containing food as far as the blood-cells are concerned.) Tea and coffee must be discarded. The diet per diem consists roughly of three pints of milk, one pint of pure water, one pound of bread, half an ounce of butter, jam *ad libitum*; this is sufficient, with the addition of prunes or a little cabbage for lubricating purposes.*

Table II.—Showing the Frequency of the Changes in the Leucocytes in Cases of Sarcoma.

No. of Case	Region	Neutrophiles			Lymphocytes		Monocytes				
		Ratio of young to old	No. of dead cells in every 100	No. of cells with pseudopods in every 100	Excess over 20 per cent	Percentage of cells showing amœboid activity	Excess over 10 per cent	Percentage of cells showing			
								Amitosis	Fatty change	Bizarre nuclei	Death
655	Retroperitoneal lymphosarcoma	1 : 1·4	0	44	++	5·7	4	7·1	7·1	14·2	28·4
708	Mediastinum	1 : 2·2	0	45	—	6·7	7	5·8	0	11·7	5·8
434	Lung	1 : 1·6	3	47	—	0	1	9	0	0	0
872	Axilla	1 : 1·2	1·1	31	—	0	1	0	0	27	0
710	Ankle	1 : 1·3	3	39	++	0	20	10	3·3	13·2	28·5
451	Kidney	1 : 2	0	20	+	0	—	0	0	0	0
693	Lymphogranuloma (Hodgkin's disease)	1 : 1·26	0	3·1	—	6·2	8	16	0	5·5	0
743	Glioma (gliosarcoma?)	1 : 1·7	5	40	—	0	5	6·6	0	26·4	0
336	Myoma uteri (myosarcoma ?)	1 : 8	20	0	+	—	3	0	0	0	23

Incidentally, these observations suggest the physiological reason for the dietary imposed upon the Hebrew race (Gen. ix. 4; Lev. xi.).

v. *Evidence of Active Amœboid Action.* This is a noticeable feature, but as it is difficult to estimate its degree with anything like mathematical precision, it is desirable at this point to dismiss it with mere mention.

When we come to consider cases of *sarcoma* in the manner described, we find very striking results. *Table II* shows that from 20 to 47 of every 100 neutrophiles present nuclear excrescences. One case (lymphogranuloma) shows only 3 per cent, and the only case which reveals none was one of myoma, clinically believed to be becoming malignant. Doubtless it is reasonable to regard this case as of quite a different type of malignancy, even if the microscope verified the clinical diagnosis, inasmuch as the sarcomatous change is an incident, and is not associated with dissemination—certainly in this particular case (see also *Fig.* 173).

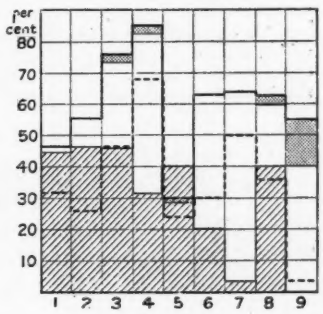


Fig. 173.—Diagram showing the Character of the Neutrophile Leucocytes in Cases of Sarcoma. The successive values (1–9) are in the same order and refer to the same cases as in *Table II*. The meaning of the different lines is explained under *Fig.* 172.

*I am indebted to Dr. Raper (Bio-chemical Department, Leeds Medical School) for guidance in this matter.

2. **Lymphocytes.**—The two tables presented take cognizance of only two points about the lymphocytes. For the sake of simplicity the bulk of the data obtained are omitted, inasmuch as no very significant conclusions have been drawn from them as yet.

The outstanding feature was in relation to *amœboid movement.* It is usually considered that lymphocytes exhibit no amœboid power. Experience shows that this statement or opinion must be modified. In the blood of both carcinoma and sarcoma there is some agent which brings out amœboid motion in lymphocytes, sometimes to a very marked degree. From this feature alone it has been possible to venture on an opinion that a case is malignant, even though the clinical evidence has been doubtful. The tables show that this phenomenon is commoner in cases of carcinoma.

Description of Plate III.—Cell-forms in Pernicious Anæmia.

The four upper rows present various forms of neutrophile leucocytes. The two lower rows show mononuclear cells. The examples are selected from different cases.

Rows 1 and 2 show marked polymorphism of the nucleus, the effect being produced by marked beading, by the extrusion of pyriform and rod-like excrescences of nuclear matter, and by coiling of the nucleus.

Rows 3 and 4 show juvenile and dying forms. Cells 11 and 18 are juvenile leucocytes (thick, rather pale, massive nuclei). Cells 13 and 14 show less bulky nuclei, with tortuosity or coil formation.

Cells 15–18 are dying cells, as shown by different staining reaction, less evident cell-outline, and less conspicuous cell-granulation. Cell 19 is introduced to show two kinds of pseudopod excrescence from the nucleus: (*a*) spiculated, (*b*) blunt and sessile. The linear arrangement of the ferment granules is also shown.

The last two rows illustrate cell-types not infrequently met with in this kind of blood. Cells 20 and 21 are large mononuclear leucocytes with bright azurophile-ex-nuclear lines. In the one case a rounded cluster of azurophile granules such as are seen in platelets is being formed. Cells 22 and 23 are typical small lymphocytes, the latter being typical of the 'naked' form so common in pernicious anæmia. 24 is a large leucocytoid mononuclear, with a fat drop in the nucleus, and another in the cell-substance. 25 and 26 are dead and dying mononuclear cells. 27 is a hyaline leucocyte (leucocytoid micro-monocyte) with a few minute azurophile granules.

Summing up the hæmatological characters of this blood, we have: (*a*) Bizarre nuclear forms, with abundant ex-nuclear pseudopods; (*b*) Preponderance of multifid forms; (*c*) A number of dead and dying leucocytes, giving the phenomenon of leucocytolysis, and indicating the existence of leucocytotoxins in the circulating blood; (*d*) Evidence of lymphocytolysis; (*e*) Presence of very juvenile lymphocytes.

The last-named point rules out carcinoma, almost with precision. Some of the other characters, which also occur in the blood of patients with cancer, merely indicate that there is something in common between the two diseases as regards metabolic processes, or as regards the configuration of the hæmolytic substances produced in each.

The microscopic appearance upon which this opinion is based has been portrayed on *Plates I, Cells* 14 and 15; and *II, Cells* 20, 21, 22, 23, 25, 26, 29, 30.

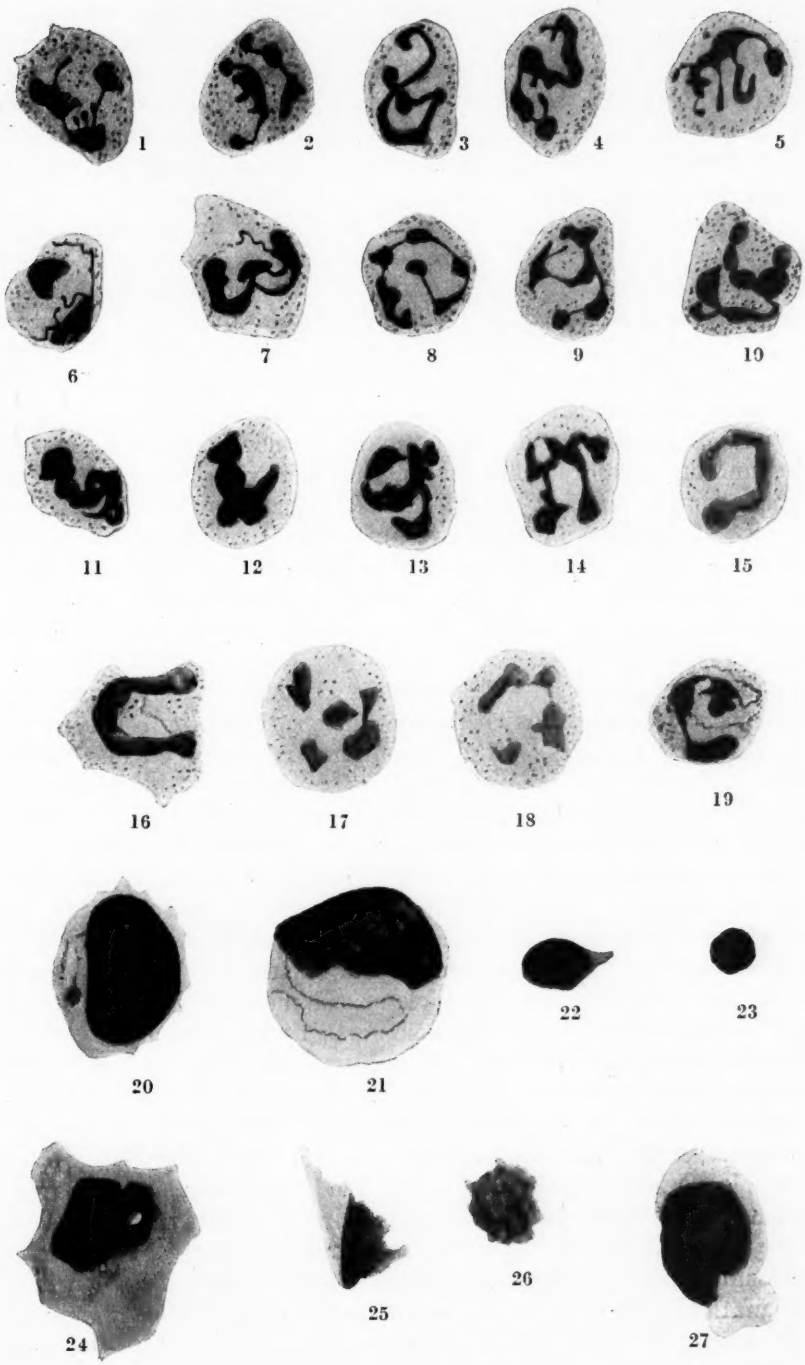
As regards the percentage of lymphocytes in the differential count, the relative neutrophilia is found to be so constant that the percentage of lymphocytes is almost invariably subnormal.

3. **Monocytes.**—For the sake of convenience we consider here the various forms of large mononuclear leucocytes, as well as what are known as 'transitional leucocytes.'

The various features which were studied, as set forth on the preliminary list, do not yield results of special interest as far as the present study goes. We therefore confine our attention to: (i) The percentage number; (ii) The occurrence of amitosis; (iii) The appearance of fatty change; (iv) The occur-

PLATE III.

CELL FORMS IN PERNICIOUS ANÆMIA



rence of bizarre forms (see *Tables I* and *II*); (v) Intranuclear markings; and (vi) Azur bodies.

i. *The Percentage Number.*—It is well known that polynuclear cells are usually increased in cases of malignant disease. Consequently, the one or other group of mononuclear must suffer in the differential count. It is found, however, that there is a greater tendency for a decrease in the lymphocytes than in that of the large mononuclears. Indeed the latter often show a relative (and therefore absolute) increase. *Table I* shows that among the carcinoma group, as many as 14 out of 24 cases give no relative increase; *Table II* shows that all cases of sarcoma but one give an increase, which in some cases is considerable.

ii. *Amitosis.*—Ross[5] has spoken of the occurrence of division of mononuclear cells while circulating in the blood-stream, and other observers have verified a fact which does not yet appear to have attracted attention on the part of the clinical pathologist. This oversight may be attributed to the inadequate staining and optical methods employed. While the condition is observable in any blood, yet it is found to be quite conspicuous in some cases of carcinoma, and in very many cases of sarcoma. In some instances the proportion between amitosing and resting forms has been estimated by the actual count of a hundred monocytes, thus verifying the results obtained by calculation from a smaller count. The appearances of the cells are quite characteristic. It is rare for the two portions of nucleus to be equal (*Plate II, Cell* 45); the commoner finding is where the portions are decidedly unequal (*Plate I, No.* 17, *Plate II, Cell* 38). Partially divided nuclei produce a bizarre apearance, as shown in several of the cells of the fifth and sixth rows of *Plate II.*

iii. *Fatty Degeneration.*—The occurrence of fine round vacuoles within the cell substance, and even within the nucleus, has been a feature of certain cases (7 times in 57 cases). The appearance is portrayed on *Plate II, Cells* 23, 32, 38, 39, 41.

iv. *Bizarre Forms.*—As stated, bizarrerie is produced by irregular and incomplete amitotic change. The nuclear contour is, however, rendered very irregular by the formation of buds (*Plate II, Cells* 46, 47, 48). The effect produced is that of " amœboid movement in the nucleus " itself. This constitutes a convenient method of description of a phenomenon which is very common in sarcomas. In carcinomas, the bizarrerie is more often produced by the in- and ex-curvation of an elongated nucleus, thus producing **C** and **S** forms (*Plate II*, first row, and the first three cells of the second row). Reference to the tables will show how frequent this feature is in both forms of malignant disease. Some of the cells may be classifiable as transitional cells whose normal horseshoe nucleus has become bent upon itself.

v. *Intranuclear Markings.*—These are not so conspicuous, but call for mention. In some instances fine spiral lines have been noted, having ten or more turns, apparently staining a purple blue, or sometimes an azur colour. They may be described as spirilloids, although they are by no means necessarily actual entities; a creasing of the cell-substance by smearing may be the explanation. In *Fig.* 174 is shown one of these cells compared with a cell from an actual tumour scraping, where a similar intranuclear marking is

present. At first sight these phenomena suggested superadded bodies, but at the present time it seems correct to regard them as belonging to the category of artefacts.

Other nuclear markings are shown in *Plate I*, *Cells* 18 and 19, and in *Plate II*, *Cells* 15 and 17, where an 'overflow' is taking place from the nucleus, producing bizarre effects. The significance of this appearance is not understood.

vi. *Presence of Azur Bodies.*—Azur granules of different kinds are frequent in both lymphocytes and in monocytes. They occur in health and in many forms of disease. The majority of observers regard them as secretory in character. Some consider them to be parasitic. There are one or two argu-

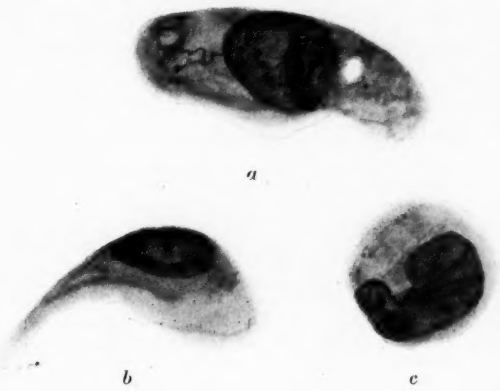


FIG. 174.—The upper of the three cells shown (*a*) is a drawing of a cell obtained by scraping a spheroidal-celled carcinoma of the stomach. A delicate spiral body is shown extending from the cytoplasm into the nucleus. This kind of body is frequent in the cells of the scraping.

The left lower cell (*b*) is very similar in staining reaction to the above; the nucleus is entirely different from an ordinary monocyte, but similar to a degenerating carcinoma cell as stained by this method. The cell is therefore diagnosed as a carcinoma cell. It is taken from a blood-film made from a case of generalized epithelioma of the pharynx, etc. (Tracheotomy necessary; patient still living.) [I am indebted to Mr. Constable Hayes for this case.]

The right lower cell (*c*) is a monocyte from the same film, showing a similar spiral body (spirilloid), partly in the cell-substance, partly in the nucleus.

All are drawn to the same scale. Panoptic stain. Oil-immersion lens, draw-tube out, Zeiss binocular eyepiece (the spiral bodies are hardly, if at all, visible with a single eyepiece).

ments in favour of the latter view, in connection with malignant disease. *Plate I*, *Cell* 11, and *Plate II*, *Cells* 27, 36, 50, 51, show special forms of azur bodies. *Cell* 27 shows a common form of diploid, the pair resembling the gonococcus. *Cell* 36 shows the azur granulation in the form of coccal chains. *Cell* 50 shows the azur body in the form of a geniculate spirillum; a similar body is shown in *Cell* 22 of *Plate I*. The occurrence of secretory granules in the form of dot lines seems unusual, although it must be admitted that similar dot lines occur in neutrophile leucocytes, being there formed of neutrophilic granules as they wind their way from nucleus to periphery of cell, and thence into the surrounding fluid medium.

4. **New Cells.**—One of these is depicted in *Plate II*, *Cell* 19. An

elongated cell-structure, with an oval nucleus near one end, strongly suggested the possibility of its being a columnar carcinoma cell which had become dislodged into some radicle of the inferior vena cava. The last row of cells on *Plate II* presents different forms of 'lymphocyte' which the writer has concluded must really be sarcomatous cells, owing to the marked difference in their morphology from an ordinary large mononuclear. Collectively, the characters of a circulating 'sarcoma' cell would be :—

Size : Much larger than a small lymphocyte, smaller than a large mononuclear leucocyte. *Shape :* Angular, tending to ovoid. *Contour :* Not very sharply defined. *Cell-body :* Relatively small, distinctly basophile, dusky, but showing no spongioplasmic network. No granules. *Nucleus :* Relatively large. Shape irregular, often budded, sometimes trifid. Outline sometimes indistinct, at other times clearly marked owing to a difference of staining reaction from the basophile cell-body. Staining power variable. Structure very finely granular rather than hyaline or striate (as in monocytes). Amitosis common. *Nucleolus :* Present in some cases.

Description of Plate IV.—Dead and Dying Leucocytes.

The illustration includes forms derived not only from the neutrophile, but also from the lymphocyte and monocyte series. The signs of death consist in (1) The defective staining power of the nucleus ; (2) Alteration in tint ; (3) Ground-glass appearance ; (4) Loss of definition of outline ; (5) Increase of size of the whole cell. The granules are preserved to quite a late stage in the process of death. The type of change has some relation to the condition from which the blood is derived. Thus the case showing 13 will not show 1 and 2.

The commonest form of necrobiosis met with in neutrophiles is represented by 1 and 2. Here the nucleus is tripartite and merely shows an altered tint (metachromatism, subchromatism).

Various degrees of disappearance of nuclear structure are shown in 5, 6, 7. 8 shows granular change at the edges of the nucleus, and a delicate fibrillation is well shown in 13 and 18. Complete loss of granules is shown in 30 and 11, almost complete in 12. 5 and 14 are abnormal cells. 15 and 16 well show the appearance of the so-called Klein-Gumprecht shadows.

Commoner shadow forms appear in 17–22, which are probably necrosed large mononuclear leucocytes (monocytes). 22 shows a monocyte with a curiously lobated nucleus, and distinct colour change in the cytoplasm (basophilic tendency).

23 shows a leucocytoid lymphocyte which has undergone marked alteration of staining reaction, the nucleus being of a much more blue colour, and the cytoplasm somewhat oxyphilic.

24 is a shadow form bearing little resemblance to a known cell. The nucleus alone remains, though in an advanced degree of dissolution.

The colouring of the cells depicted is that shown by the use of the panoptic stain described in the text. The magnification is approximately 700.

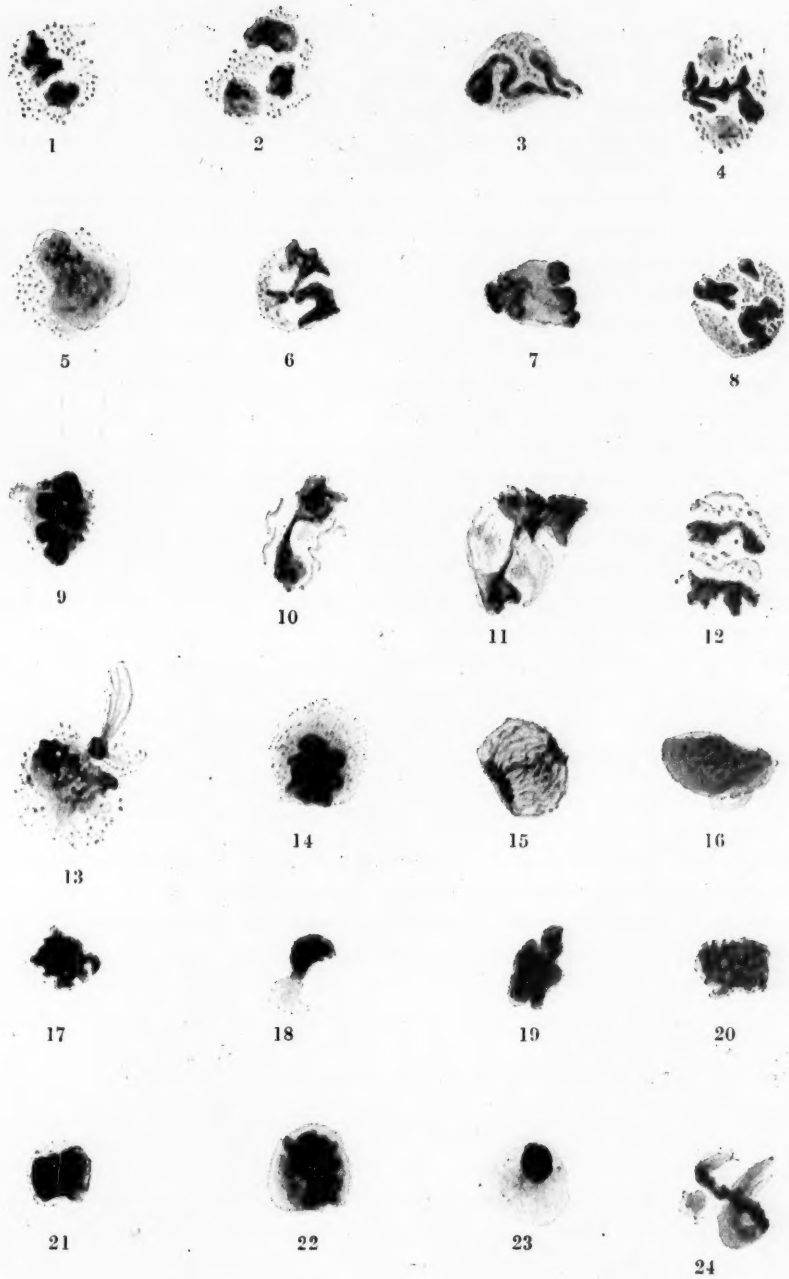
The colouring and drawing in *Plate II* is partly diagrammatic.

This description does not cover all the possibilities, because a larger number of cell-forms in a larger number of cases must be studied.

5. **Platelets.**—The character of the platelets in the blood-smear of cases of malignant disease is sufficiently striking to merit careful investigation. The frequency with which these bodies are actually adherent to the leucocytes, and the frequency with which they appear to be manufactured within the nuclear substance, and then within the cell-body (*Plate I, Cells* 20, 21, *Plate III, Cells* 20, 21), suggest some close relationship between the two series of structures. A cell like that on *Plate II, Cell* 56, shows apparent fusion between the platelet and the tumour cell. This appearance is by no means isolated. It has reminded one of Ross's theory of autofertilization of body-cells by the functioning of other body-cell outpourings as male gametocytes.

PLATE IV.

DYING AND DEAD LEUCOCYTES



The interest attaching to these bodies is not so much one of diagnosis as of etiological relationship. If these phenomena indicate the existence in the serum of special forms of agglutinins, a combination of the present method of study with other laboratory methods might be productive.

IV.—RELATION BETWEEN BLOOD-CELL FINDINGS AND CLINICAL PHENOMENA.

A study was made on several occasions in a case of Hodgkin's disease (lymphogranuloma), where the blood-smear showed evidence of sarcomatous processes having begun. (I am indebted to Dr. Telling for permission to use this case.) The case passed through several pyrexic periods running in cycles. The temperature was intermittent, and the rises were accompanied by rigors. *Figs.* 175 and 176 represent the results of the investigation on two occasions. A twenty-four hour cycle is recorded, the differential count having been carried out on hourly specimens. The position of the rigor, with the temperature rise, is shown. It is seen that there is a decided increase in the proportion of dead neutrophiles just before each rigor. It is also seen that 'sarcoma' cells appear in the blood-stream, as the temperature rises to its acme. The smaller chart (*Fig.* 175) demonstrates the relation between the monocytes and the temperature change. It is seen that these cells fall very markedly at the time of the rigor, to re-ascend as the temperature declines. The 'sarcoma' cells have been increasing until the time when the temperature ascends. Both charts, from the same patient, show that the cycles did not uniformly correspond. An explanation may lie in the fact that the first experiment was carried out in the middle of a three-weekly pyrexic period, while the latter one was towards its decline.

The finding is reported partly for its interest, and partly to demonstrate that it is possible to obtain more intimate knowledge regarding the inner processes of disease by a comparatively simple procedure, the only appliance needed being the microscope.

V.—GENERAL SUGGESTIONS.

Evidence has been brought to show that a fine morphological study of the blood-cells may convey further information about the processes of disease. A morbific agent may stimulate the leucocytes to greater activity—be it phagocytic (amœboid movement) or reproductive; it may damage the leucocytes, and cause the proportion of 'dead and dying' leucocytes to increase; or it may bring about the appearance of new structures within the cells.

In assessing the various findings, it is necessary to remember that the cellular composition of the blood depends upon—(1) The actual composition of the serum; (2) The degree of vitality of the cells; (3) Individual idiosyncrasies.

The blood-cell formula, as studied by more detailed methods, furnishes a clue to the chemical composition of the serum. The same principle must hold for the blood (whose cellular composition is a reflection—more or less precise—of the cellular composition of the floating population of the tissue spaces) as holds good for the infiltrating cells of morbid tissues. Whether the

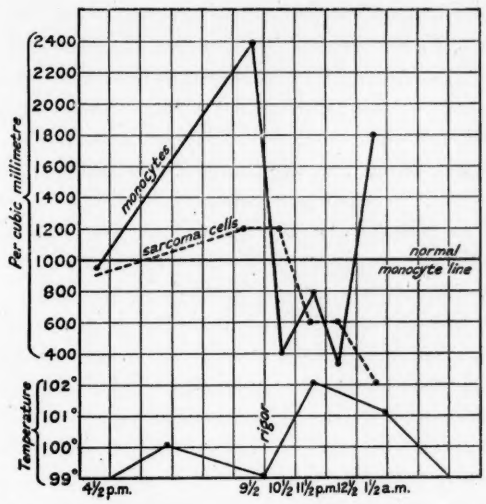


FIG. 175.—CASE OF LYMPHOGRANULOMA. Hourly variations in the numbers of certain circulating cells during a febrile period.

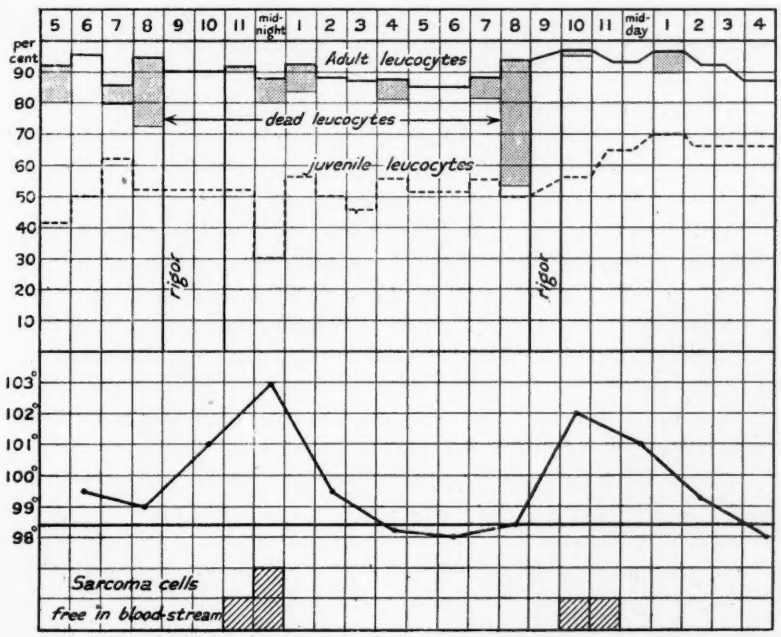


FIG. 176.—FROM THE SAME PATIENT AS FIG. 175.—A complete twenty-four hour cycle, showing the proportions of certain blood-cell types from hour to hour. Note the increased mortality of the leucocytes just before a rigor, and the appearance of 'sarcoma' cells after a rigor.

inflammatory infiltration is polynuclear, lymphocytic, eosinophilic, fibroblastic, and so forth, depends on the nature of the chemical substances which are stagnating in that given area. These substances are in turn dependent upon the type of organism present. If we divide the organisms into (1) cocci

and exotoxic bacilli, (2) endotoxic bacilli and acid-fast bacilli, and (3) protozoa, we have three types which are responded to by three types of inflammatory cell exudate; and we have the same types of blood-cell 'leucocytosis.' But it is not the organisms (as organisms) that evoke the infiltration, it is the kind of substance which constitutes their respective excrement. The neutrophile can deal with the one, the lymphocyte with the other, the monocyte deals with solid residues. Exactly what sort of formula appears, depends on a number of factors, which are well enough known. The only point of importance is to realize that *the same factors hold good in the determination of the blood-cell formula*, the 'differential count.'

It is unscientific to expect a certain cell-count in a certain *disease*; therefore it is necessary to emphasize the fact that *a cell-count merely means that such and such chemical substances are circulating* in the blood at that given time. If these substances are of such a nature as to cause unusual changes in the morphology of individual cells, then they can be identified. The blood-cell picture is a pattern corresponding to the type of abnormal substance circulating, and is not concerned with the clinical diagnosis, excepting at the crest of a cycle where special symptoms come into view.

With these reservations, it may be regarded as possible to make a diagnosis of malignant disease, conclusively, from a careful study of a single blood-smear. It is possible to distinguish between carcinoma and sarcoma.

The object of the blood examination, therefore, is to determine whether the blood contains: (*a*) Leucocytotoxins—shown by various grades of 'death' of the leucocyte. (*b*) Leucocytotic substances, i.e., bodies which either stimulate leucocytic proliferation, or attract leucocytes into a more confined area than is customary, or actually irritate the individual leucocyte; the latter is shown by abnormal nuclear outlines, and superadded structures of various kinds. (*c*) Products of metabolism; these may be natural, or peculiar to certain pathological processes. Cases of malignant disease are characterized in many instances by the discharge into the blood of substances belonging to each of these groups.

A further point is that the student of the blood-smear is in search of certain aberrant cell forms, and not a percentage valuation. The figures which are here presented are solely for the purpose of fixing certain findings before the reader. To attempt to force the value of a percentage, in its bearing on a clinical diagnosis, implies neglect of certain fundamental principles in biology. If we find a certain type of cell or certain intracellular changes with frequency, we are enabled to conclude that some abnormal bodies are circulating in the patient's blood, and that these may or may not (probably do) account for his symptoms.

A class of case where this argument becomes of value occurs in pernicious anæmia, which notoriously simulates gastric cancer. This is presumably because the carcinoma has damaged the same portion of gastric mucosa as is diseased in pernicious anæmia. The blood picture is therefore similar. *Plate III* illustrates some of the important differences. The main feature is the abundance of small ('naked') lymphocytes in the anæmia, and the marked diminution of the total white-cell count. Dying cells are much more

common in pernicious anæmia, and bizarrerie of the neutrophiles is rather less frequent.* The changes described in carcinoma under the heading of monocytes are almost peculiar to this disease.

SUMMARY.

1. The cell-findings in a blood-smear vary in health, under the influence of diet.

2. The findings vary in disease according to the type of product of the causative agent, and not according to the agent itself.

3. The findings in malignant disease vary according as the mass is actively growing or not, according to its limitation by fibrous tissue or not (no discharge of specific excretion into the juices), and according to the gross mechanical effects of the neoplasm on the body (starvation, hæmorrhage).†

4. Monocytosis is a frequent accompaniment of protozoan infections. It is also decided in some cases of carcinoma and in many cases of sarcoma.

5. Since one phase of the blood-picture produced by circulating toxins of malignant disease can be imitated by ingestion of highly nitrogenous food, it suggests that long-continued over-use of the same may form an advantageous substratum for the subsequent development of the disease.‡ While this statement has only speculative value, there is a practical value in the fact that blood-smears should be taken before a meat meal, or preferably after instituting a purin-free diet for one or two days before.

Investigations upon blood-cells up to the present enable the following rules to be formulated :—

If the smear shows neutrophilia, and fat drops in many of the neutrophiles ; if the nuclei of the neutrophiles are largely multifid : the case is one of a coccal infection of great or very great severity.

If the smear shows a relative abundance of lymphocytes (especially of the very small variety) ; if there is no leucocytosis ; if multifid nuclei preponderate : the case is almost certainly *not* one of malignant disease.

If there is neutrophilia, with bizarre forms, or pseudopods in number ; if the lymphocytes are in many instances showing amœboid outlines ; if the monocytes show amœboid nuclei (see central portion of *Plate II*, which contains cells from a single smear) : the case is almost certainly one of malignant disease.

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[1] *Practitioner*. 1915, Nov., 676.
[2] *Dominion Med. Monthly*, 1912.
[3] *Biology of the Blood Cells*. J. Wright & Sons Ltd., Bristol, 1913.
[4] *Jour. Path.*, 1915, April, 494.
[5] *Proc. Roy. Soc. Med.*, McFadyean Researches, etc.

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* The subject of differential diagnosis is being reserved in connection with a joint study upon pernicious anæmia with Dr. Telling.

† And according to co-existent bacterial infections.

‡ It may also mean that the cleavage products of the food resemble those of carcinomatous excretion.

THE PREVENTION OF DEFORMITY FOLLOWING FRACTURE OR RESECTION OF THE JAW.

A PLEA FOR THE EARLY USE OF SUITABLE SPLINTS.

By W. H. DOLAMORE, London.

The frequency of injuries to the jaws during the present War lends special importance to a consideration of the various splints which are available for their treatment.

The cases fall into two distinct groups: First, those in which the jaw is fractured in one or more places, but no bone is lost. Secondly, those in which the injury is accompanied by destruction of bone, and frequently, also, of the overlying soft tissues. The treatment in both groups of cases has this in common, that the portions of jaw must be placed and kept in their correct positions, so that afterwards the teeth may articulate properly with their opponents.

In the second group of cases there is added the further problem of preventing facial deformity. If, for instance, a portion of the mandible at the symphysis be lost or removed, then, unless a splint be inserted, the two remaining pieces of bone will inevitably fall together; the teeth will not articulate with those of the maxilla (see *Figs.* 186 and 192), and the face will be deformed. If the union be fibrous, treatment is possible but tedious; if bony, treatment must involve section of the bone—in other words, must begin *de novo*. Further, if coincidently with the loss of bone, the skin over it has also been destroyed, then a plastic operation is necessary. Now, if a properly-made splint be inserted, not only will the remaining portions of bone be fixed in their correct positions—a great assistance to the surgeon in his subsequent task of fashioning and adjusting the skin flaps—but if the contraction of the scar tissue be prevented, experience suggests that the newly formed fibrous tissue will disappear, leaving the tissues soft and movable. *Per contra*, if no splint be used, the size of the flaps may be underestimated, and in any case contraction will follow. Thus, to the disfigurement of a deformed mandible may be added a contracted lip.

Splints, consequently, fall into two classes: first, those used in the treatment of fractures; and next, those employed after the removal of tissue by operation or injury. The methods described are based on experience gained chiefly in hospital work during many years; and although admittedly there are essential differences between civil and military practice, yet these cases have value in that they happened sufficiently long ago to enable the ultimate result to be known. At present this is true of few military cases. For instance, 'somewhere in France' fractures are being treated by wire sutures in cases which experience has shown could easily and properly have been treated by

splints. The results in three such cases are seen in *Figs.* 184, 185, 186, 199, and 200.

In the treatment of fractures the splint used should fulfil the following conditions. It should be easily made, and be inexpensive. It should guide the displaced portions of bone into their correct positions and fix them there. It should not cover the soft tissue, that is, the gum, nor injure it. It should be easily fixed in place. It should allow the mouth to be opened for cleansing and feeding purposes, and as soon as may be, permit soft food to be chewed. In an attempt to attain some of these objects many splints have been designed, but since they failed in one or another direction—generally in being too elaborate and expensive—they at no time met with general acceptance, and have ceased to be used.

In point of time one of the first splints to be used was the Tomes splint or Mutter's clamp. This consisted of a metal cap covering the teeth loosely and, in the forms figured, also the gum. It was lined with gutta-percha, which

FIG. 177.—THE METAL CAP SPLINT.

actually fitted it to the teeth and caused it to adhere slightly to these. This splint is interesting since it is the father of other forms of cap splints. With the introduction of vulcanite it fell into disuse, being supplanted by the Gunning.

The Gunning, for all practical purposes, is a Tomes splint made in vulcanite. Neither the Tomes nor yet the Gunning really grasped the teeth. They required external bandages. The jaw, being gripped by the bandage, forced the teeth into the splint, which in turn was pushed against the upper teeth, and so held. Thus the mouth could not be opened for cleansing or feeding purposes without disturbing the fracture. Hence arose a modification.

To the Tomes splint, Howard Hayward soldered two metal arms which, passing out at the angle of the mouth, curved backwards outside the cheeks. The splint being in place, a narrow bandage was carried from one arm to the other, passing under the chin. Hence the mandible was gripped between the bandage and the splint, allowing the mouth to be opened when necessary. To the vulcanite Gunning splint Kingsley added, at a later date, the same modification. Neither the Hayward nor the Kingsley are often used now in

the treatment of fractures of the mandible unless teeth are absent; but the principle involved is of distinct value in the treatment of those fractures of the maxilla which separate this bone from the cranium. In such cases the arms are fixed to a vulcanite plate covering the gums and palate in the case of an edentulous patient, or, if teeth be present, to the metal cap splint (*Fig.* 177) described later. The maxilla is then fixed in position by means of bandages passing round these arms and over the top of the head, or else by straps passing from the arms to a closely-fitting skull-cap.

FIG. 178.—THE HERN MODIFICATION OF THE GUNNING SPLINT.

When the teeth are covered by a vulcanite cap, unless the cap be very carefully adjusted to the articulation, the back portion will gag the mouth open, so that the front teeth will not touch the cap. This frequently happened with the Gunning splint, the splint tending to tilt and rise in front. This difficulty was met by the Hern modification (*Fig.* 178), which consists in building on the articulating surface of the splint on both sides, where it covers the lower molars, blocks of vulcanite with impressions into which the upper molars bite. Thus the mouth is purposely gagged open, facilitating its cleansing, and the feeding of the patient.

An earlier modification of the Gunning, the double Gunning (*Fig.* 179) consists of two vulcanite caps, one covering the lower teeth, the other the upper, these being fastened together at the back, but separated in the front. In simple fractures of the mandible there appears to be no advantage in the use of the double Gunning over the ordinary splint; indeed, to cover the upper teeth also, is to add to the difficulty in keeping the mouth clean. But the splint is of value in the treatment of fractures of the upper maxilla, and can be used with advantage in the treatment of fractures of either mandible or maxilla when no teeth are present either in one or in both.

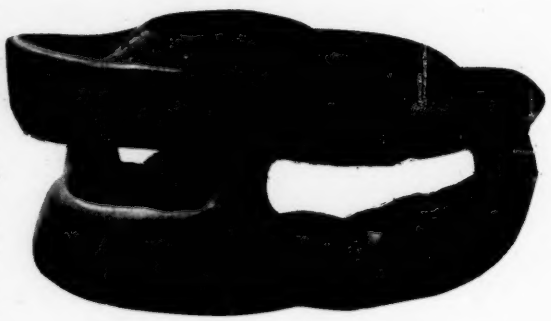

FIG. 179.—THE DOUBLE GUNNING SPLINT.

All the splints so far mentioned fail to meet several of the conditions laid down. They guide the ends of the fractured bone into their correct positions, but do not fix them there without the assistance of external bandages. The mouth cannot be opened for cleansing purposes save at the risk of moving the fractured bone; indeed these splints themselves act as dirt retainers, and are always exceedingly foul. Even when the bone is sufficiently united to allow the removal of the external bandages, the splints must still be worn for a

time, and during the whole of this period nothing but quite a fluid diet is possible. Still, in default of the evolution of better methods, they are of use in the cases indicated.

The Hammond splint (*Fig.* 180) marked a great advance. It consists of a wire fitted to the necks of the teeth, and retained in place by wire ligatures passing between the teeth and over the wires. It is a very cheaply and easily made splint, since soft galvanized iron wire answers admirably. But it does not guide the portions of bone into their correct positions, and it is tedious to adjust, many ligatures being necessary before the fracture is securely fixed; hence considerable pain is caused. Food tends to hang about the wires; but this

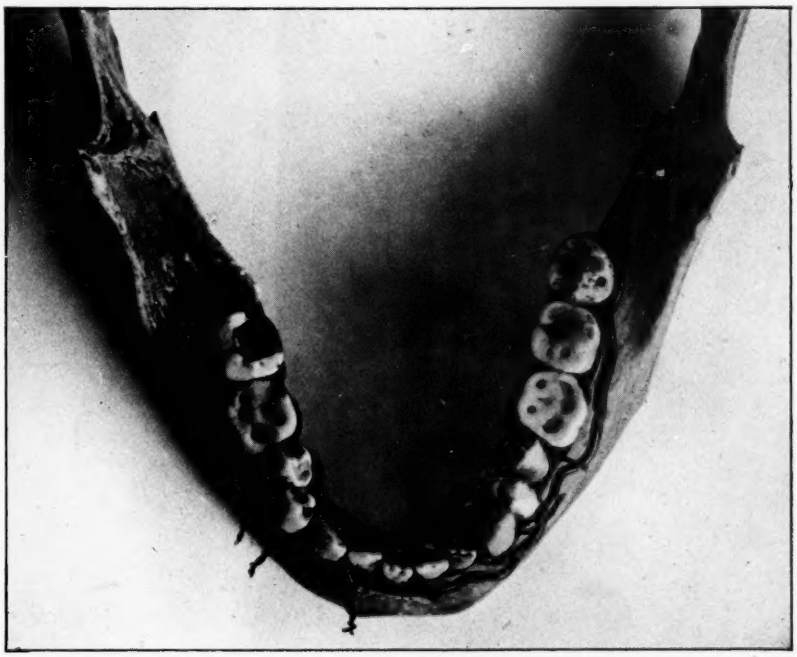

FIG. 180.—THE HAMMOND WIRE SPLINT.

can be readily removed, for the mouth can be freely opened, no external bandages being essential. The splint is, however, useless unless teeth be present in each of the bony fragments.

Another method of treating fractures consists in making the teeth of the upper jaw the splint for the lower, the lower teeth being fastened to the upper. This is usually done by fastening round several teeth what are known as Angle's bands. Binding wire is then wound round the studs of the bands on the lower and upper teeth till fixity is attained. Given an alternative, this treatment seems needlessly cruel. It does not allow the internal surfaces of the teeth to be cleansed, and interferes with the taking of food. Nevertheless it is useful in treating fractures of the neck of the condyle, or cases in which there is loss of bone in the region of the angle. This method has the great advantage that the appliances can always be available and immediately

applied. It should have been used in many military cases, due to gunshot injuries, in which bone has been lost at and about the angle. Many such appear to have been left untreated for several weeks; as a consequence, the contraction of scar tissue has drawn back the horizontal ramus, leaving the front teeth displaced backwards and downwards, and widely separated from the uppers. In several cases subsequent treatment has only alleviated, and not cured, the deformity.

The Lewin Payne cradle splint (*Fig.* 181) may be regarded as a further development of the Hammond. It consists of two wire frames fitted round the necks of the upper and the lower teeth respectively, these frames being connected by vertical wires passing from one to the other and soldered to each. This splint fixes the mouth slightly open, and therefore the wound can be syringed and kept clean. Though it has been used with success, it does not

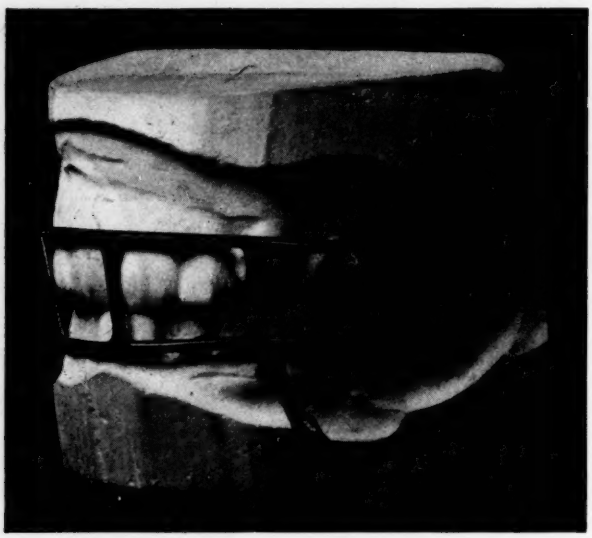

FIG. 181.—THE PAYNE CRADLE SPLINT.

seem to meet all the conditions laid down. For fractures of the horizontal ramus of the mandible, when teeth are present in all the fragments, it does not seem to offer any great advantage over the Hammond splint. Nevertheless, in fractures of the angle where there is displacement upwards of the anterior portion, it is useful; it can also be used as an alternative to the Hayward in fractures separating the maxilla from the cranium. When one jaw is edentulous, but teeth are present in the other, a wire cradle for the latter, attached to a vulcanite or metal plate covering the former, is more cleanly than a double Gunning, and should be used in preference in the cases previously indicated.

The splint which meets the stated conditions most nearly is the metal cap splint cemented to the teeth. The writer has used this with success for some years, and it is being largely used by others. It consists of thin metal, cast or struck up to cover and closely fit the crowns of the teeth, but cut away at the neck, that is, at the gum margin. Having been made to a cast on which

any displacement of the fractured bone has been corrected, it follows that when the teeth are pressed home into the splint the fracture must be properly set. This is true also of the Gunning and of the Tomes when lined with gutta-percha; but whereas these do not retain the teeth in position, the cap splint does, for it is cemented to the teeth. For this purpose the cement (white stopping) used for filling teeth is employed. The splint is dried, and also the natural teeth as much as possible; the cement is now mixed, and the cap filled with it. The cap is then forced home or, more correctly, the teeth forced into it by pressure on the lower border of the mandibular fragments. An anæsthetic may be given if necessary; in any case a pad of wool should protect the

FIG. 182.—FROM A SKIAGRAM: SHOWING THE CAP SPLINT IN PLACE.

skin over the bone from the pressure of the fingers. Before the cement has set, the splint, when in place, can be closely pressed against and between the teeth with suitable forceps. After the cement has set, the excess is chipped away. If the splint over the molars raises the bite, the caps there can be ground off; but there appears no advantage in purposely perforating the splint at the cutting and grinding surfaces of the teeth, as has been advocated, since, when being forced home, the pressure on the cement is greater with the caps intact, and hence the splint is more securely 'stuck on.' Further, the cement being slightly porous in texture when set, the less it is exposed the better, since it tends in time to become foul. A similar splint was used by the writer for fixing teeth in their proper positions in the immediate method of correcting

misplaced teeth after alveolar section. Some fifteen years ago he extended its use to the treatment of fractures, and has used it since to the exclusion of other methods. Quite independently, the idea has occurred to others, and at present it is being more frequently used in Paris than any other form of splint.

In simple cases, seen immediately, when the teeth are good and the mouth clean, fractures so treated make an uninterrupted recovery. No external bandages are required; the patient is soon able to take soft food, and to go out and about doing his daily work, if not of a laborious character.

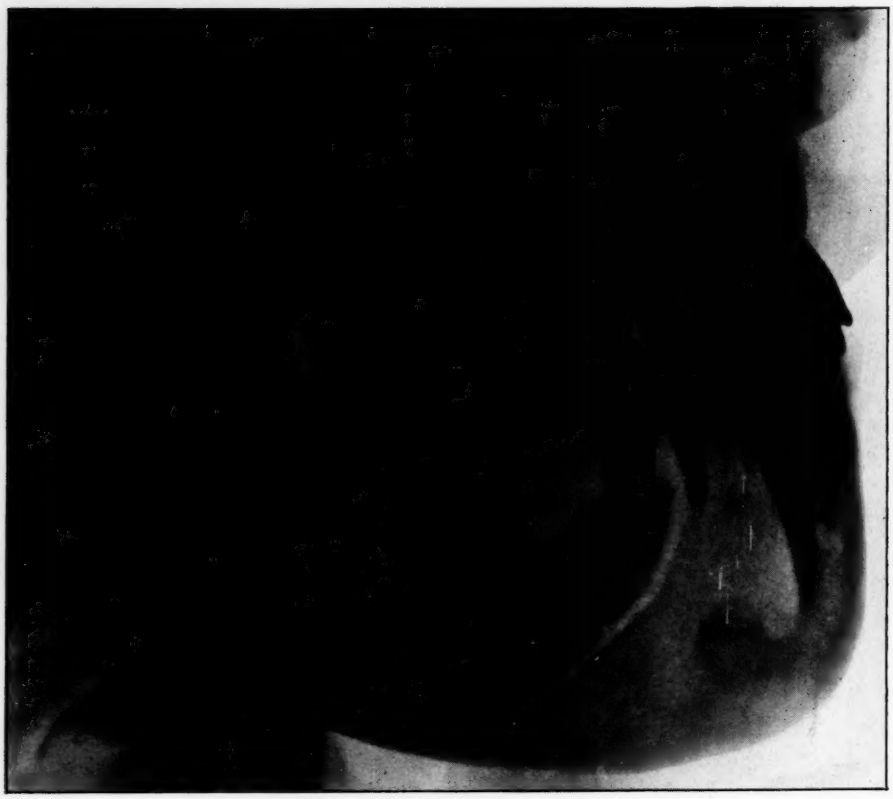

FIG. 183.—ANOTHER VIEW OF THE SAME CASE AS FIG. 182.

There is little reason to doubt that complications, as submandibular abscess, necrosis, etc., are largely prevented if the case is seen and a splint fixed early. It is true that with the use of external bandages only, many cases get well, and the union, though perhaps not ideal, is fairly correct. Under some circumstances splints may not be available. It is said by Mr. Hacking that this is at present the case in the Navy, where fractures happen as accidents of ordinary ship life. Mr. Hacking also states that the results are good. All patients, however, do not lead a healthy ship life, nor receive the attention of the sick ward. By way of contrast to what the patient may expect with the splint treatment described above, there may be quoted, in an

abbreviated form, the directions given by Mr. Pickering Pick for the treatment by a four-tailed bandage: "The patient is to suck fluid nourishment between his teeth. He may not speak, but shall use a slate. After three weeks he may have soft food, may masticate after five, but should still wear a handkerchief tied round his head to prevent violent movements of the jaw."

Figs. 182 and 183 show a cap splint in place. The patient, a soldier who fell out of a train, had a triple fracture of the mandible, one on either side in the canine region, and a third posterior to the last molar, the line of fracture running

FIG. 184.—FROM A CASE OF FRACTURE TREATED WITH A CAP SPLINT.
It also shows an earlier attempt to treat by wiring.

downwards and backwards, but with no displacement of the bone. The man came direct to the Royal Dental Hospital; the splint was fixed the following morning; no external bandages were used; no submandibular abscess formed.

Fig. 184 is the skiagram of another fracture for which this splint was used. It also shows an earlier attempt to treat by wiring. This had totally failed to promote union; indeed, when seen, the teeth on either side of the seat of fracture separated as the mouth was opened. The separation of the fragments during opening the mouth is sometimes very marked. A notable case was that of a boy, the victim of a motor accident, who in addition to other severe

head injuries, had a fracture of the mandible in the mid-line. Whenever the mouth had to be opened, the wound gaped to the extent of half an inch. A cap splint was used, and answered admirably. Any other form of splint would have been very difficult, or impossible, to adjust.

Fig. 185 shows a badly united fracture, the union being fibrous, which should have been treated with a cap splint. The skiagram shows evidence of the attempt to wire the fragments. The amount of absorption caused by the

FIG. 185.—SKIAGRAM SHOWING A BADLY UNITED FRACTURE WHICH SHOULD HAVE BEEN TREATED BY A CAP SPLINT. The union was fibrous.

sutures is worth noting. A piece of bone necrosed and separated, and the remaining portions fell together, leaving the deformity shown in *Fig.* 186.

Some modifications of this splint have been made. The first was designed to treat cases, not infrequently seen, in which no teeth are present in the posterior fragment, the fracture being in the premolar region. *Fig.* 187 shows such a case, which is exceptional in that there was no displacement of the fragments. The question of the use of a splint at all in this case might arise; nevertheless, the fact that the patient was not seen for several days after the

injury, the fracture originally being overlooked, suggested it to be advisable. *Fig.* 188 shows the splint in place. A cap covers, and is fixed to, the teeth; a wire soldered to this, arches backward over the seat of fracture, and is attached to a shield of metal resting on the gum over the posterior fragment. Thus the upward displacement of this portion by muscular action is prevented. In

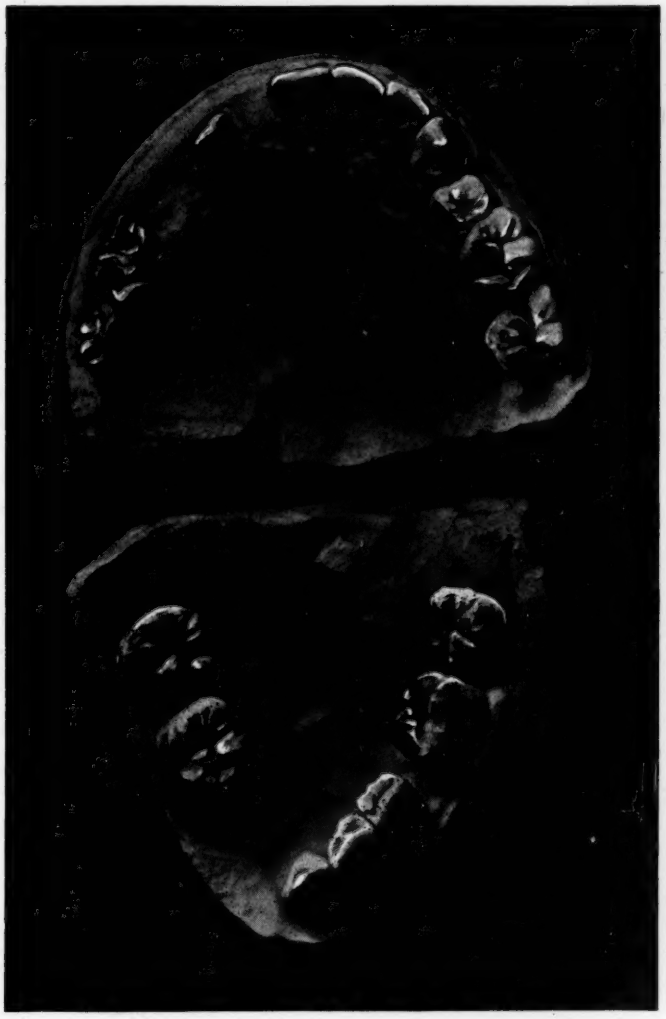

FIG. 186.—THE SAME CASE AS FIG. 185, SHOWING THE DEFORMITY WHERE THE BONES FELL TOGETHER.

this case sequestra afterwards separated at the seat of the fracture, and displacement must have followed but for the splint.

A second modification is designed to treat those cases in which the teeth are not in complete series. Then the splint becomes two or more separate caps covering teeth or groups of teeth, these being joined by a metal rod placed

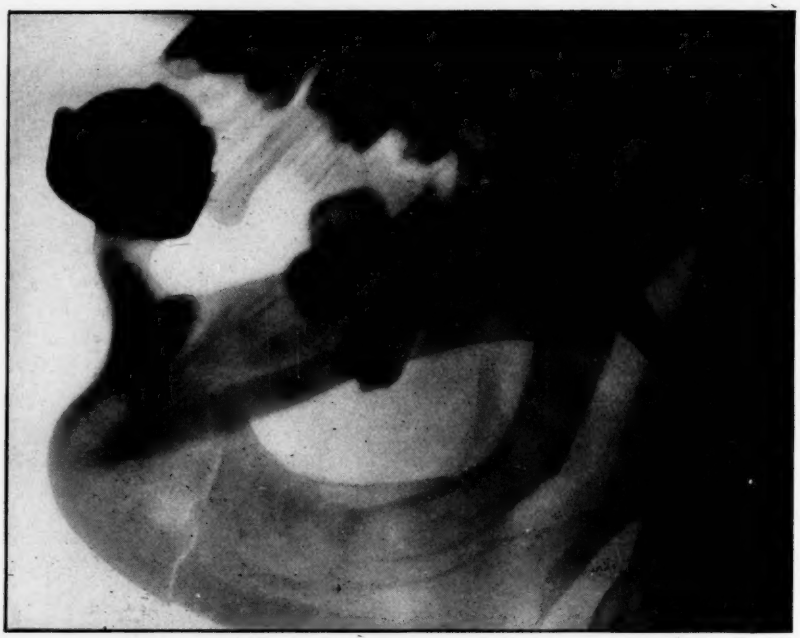

FIG. 187.—TO SHOW A MODIFICATION OF THE CAP SPLINT WHERE NO MOLAR TEETH ARE PRESENT.

FIG. 188.—THE SAME CASE AS FIG. 187, SHOWING THE SPLINT IN PLACE.

as far from the gum as possible. Hence the gum is not covered; it can be kept clean, and if sequestra separate they can be easily removed from under the rod.

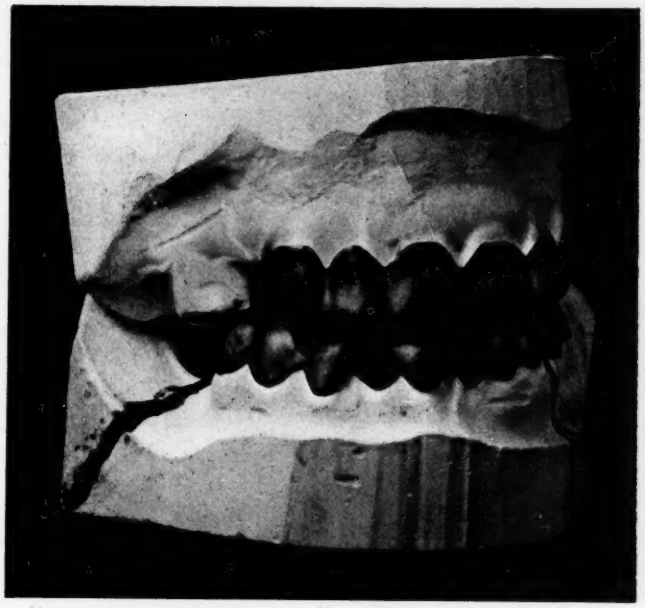

FIG. 189.—THE DOUBLE CAP SPLINT, A SUBSTITUTE FOR THE PAYNE SPLINT SHOWN IN FIG. 181.

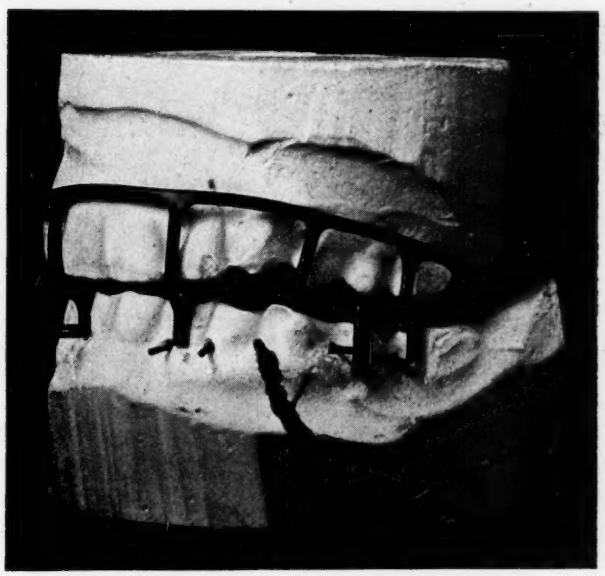

FIG. 190.—DOUBLE CAP AND WIRE SPLINT.

For the group of cases for which the Lewin Payne splint was designed some have used a double cap splint (*Fig.* 189). This consists of two caps, one

for the upper, the other for the lower teeth, soldered together. It is difficult to cement in place, and one or other is apt to come 'unstuck.'

Mr. George Northcroft has used a cap splint cemented to the lower teeth, joined to a cradle splint wired to the upper, and has further modified it by cutting away the front of the cap so that the labial surfaces of the lower teeth are exposed. Four or five vertical rods pass from the margin of the cap downwards towards the gum; not only is the cap cemented in place, but it is also fixed by wires passing through holes in the splint, then on both sides of a tooth, and finally twisted over a rod (*Fig.* 190). It will be noticed that by

FIG. 191.—FROM A CASE OF COMMINUTED FRACTURE, THE RESULT OF A GUNSHOT WOUND.

the last modification the splint is becoming far too elaborate to construct for ordinary cases, and in the writer's opinion unnecessarily so; but in some cases Mr. Northcroft has found it to have advantages.

During the War a number of gunshot wounds have been associated with loss, or excessive comminution, of the mental portion of the mandible. Often it seems impossible to predicate whether or no bony union will follow. In any case the wound is very foul, and the shedding of sequestra, large or small, will continue for many weeks. In the case illustrated in *Fig.* 191, a piece of the crown of a tooth was cast off three months after the injury, showing how the

parts get churned up; yet in this case bony union followed. Hence the splint must not interfere with the irrigation and cleansing of the wound, nor with the removal of the sequestra. Yet the early fixing of a splint appears to be imperative for the following reasons: If the remains of the mandible are fixed, the patient is saved much pain; it has been noted that in many cases when gunshot wounds have been inflicted on the mouth and also in one or more of the extremities, it was the oral wound which caused the greatest pain, both at the time of infliction, and later during treatment. Again, the use of the splint retains the parts at rest; hence it assists healing, and allows the mouth to be more frequently and thoroughly cleansed. Lastly, and chiefly, the splint prevents malunion, or, if the union be fibrous, displacement by cicatricial contraction of the remaining portions of bone, thus preventing those permanent deformities which have been seen far too frequently of late.

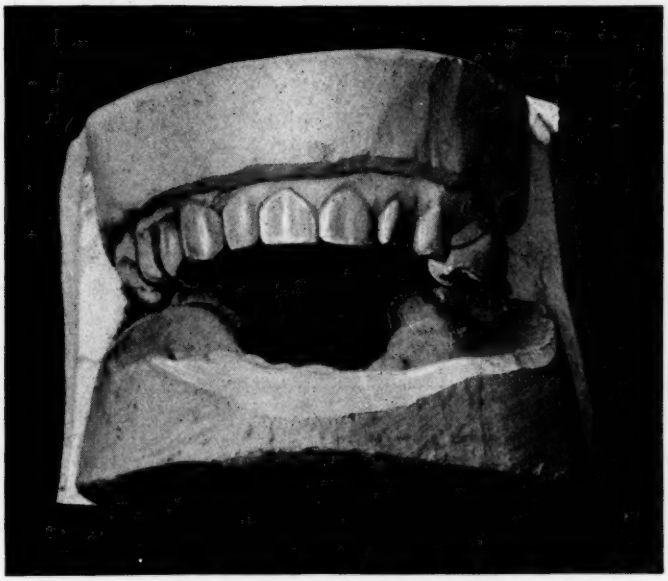

FIG. 192.—A CASE OF GUNSHOT WOUND CALLING FOR THE USE OF A SPLINT TO PREVENT PERMANENT DEFORMITY.

In the cases actually seen, or of which the writer has casts, molar teeth frequently have been present in the uninjured portions of the mandible (*Fig.* 192). The splint used, or which should have been used, consists of a cap splint moulded and cemented to these teeth, the caps being joined by a stout wire bent to the normal curve of the jaw. If a portion of bone is destroyed and removed, a shallow metal trough, corresponding to the lower border of the mandible, may take the place of the wire. But in some cases this trough is reported to have interfered with drainage, and to have produced a depression full of pus. Probably the use of drainage tubes would have been an advantage.

When fibrous union has already taken place, and displacement inwards of the two sides of the mandible has resulted from the contraction of the scar tissue, attempts may be made to correct the deformity, and good results have

been obtained. The caps of the splint, instead of being joined by wire, have a jack screw inserted between them, and are slowly forced apart. In a Paris hospital, instead of a screw Dr. Holtz uses successfully a spring, which slowly separates the two portions. Mr. Rodway, in a paper read before the Manchester Odontological Society, states he has obtained a partial improvement by stretching the portions apart at the time of the insertion of the splint. Owing to the difficulty of keeping the portions apart and fixing the splint as a whole, he divides the wire between the caps, and makes the ends to lap over, each having a shoulder. Each half of the splint is separately fixed, the remains of the mandible being then pulled apart till the overlaps of the wires are in correct position; these are then fixed together by a screw.

Some of the patients seen have been further deformed by a contraction of the lower lip. The insertion of a vertical metal plate moulded to lie immediately behind the lip line, and fixed to the wire, or the trough of the splint, would not only have prevented the contraction, but if a plastic operation was needed, would, as previously suggested, have assisted in the estimation of the

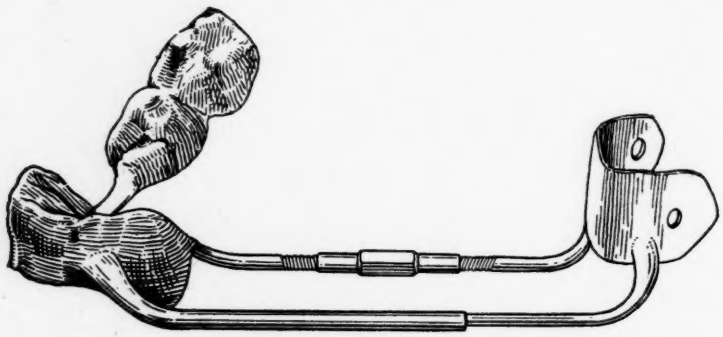

FIG. 193.—COMBINATION CAP AND WIRE SPLINT USED WHERE BONE HAS BEEN LOST FROM THE POSTERIOR PORTION OF THE MANDIBLE.

size and in the adaptation of the flaps. It is admitted that the condition of the patient may contra-indicate any operation of a complicated nature; but if the surgeon be able to perform a plastic operation, it is contended that the fixing of a splint would not complicate, but rather assist matters.

A further modification of this splint is adapted to the treatment of those cases where the posterior portion of the mandible, including more or less of the ascending ramus, has been lost. Its use is perhaps more clearly indicated when the bone is removed because of the presence of a tumour, than when its loss follows a gunshot injury, with the coincident septic wound.

The following cases illustrate its use:—

Because of a growth, Mr. Pepper removed the left portion of the mandible, extending from the mid-line to about half an inch below the sigmoid notch. After the removal of the bone and arrest of hæmorrhage, but before replacing the skin flaps, the splint shown in *Fig.* 193 was inserted. The cap splint was cemented to the teeth in the remaining half of the mandible, whilst the anterior inferior angle of the remains of the ascending ramus was placed to lie loosely in the hood. The skin flaps were then replaced, and the mucous membrane

brought under the wires connecting the cap and hood, and sewn to that of the skin flap. Subsequently the hood and posterior portion of the wire became embedded in granulation tissue. This splint remained in place for about three months, the patient being able from the first freely to open her mouth; there was no displacement of the remaining half of the mandible, and little external deformity of the left side of the face. But a small sinus persisted, running up to the cap, due either to its presence, or, as Mr. Pepper thought, to the necrosis of splinters of bone, which was much thinned by the growth, and splintered freely when divided. Therefore the splint was removed

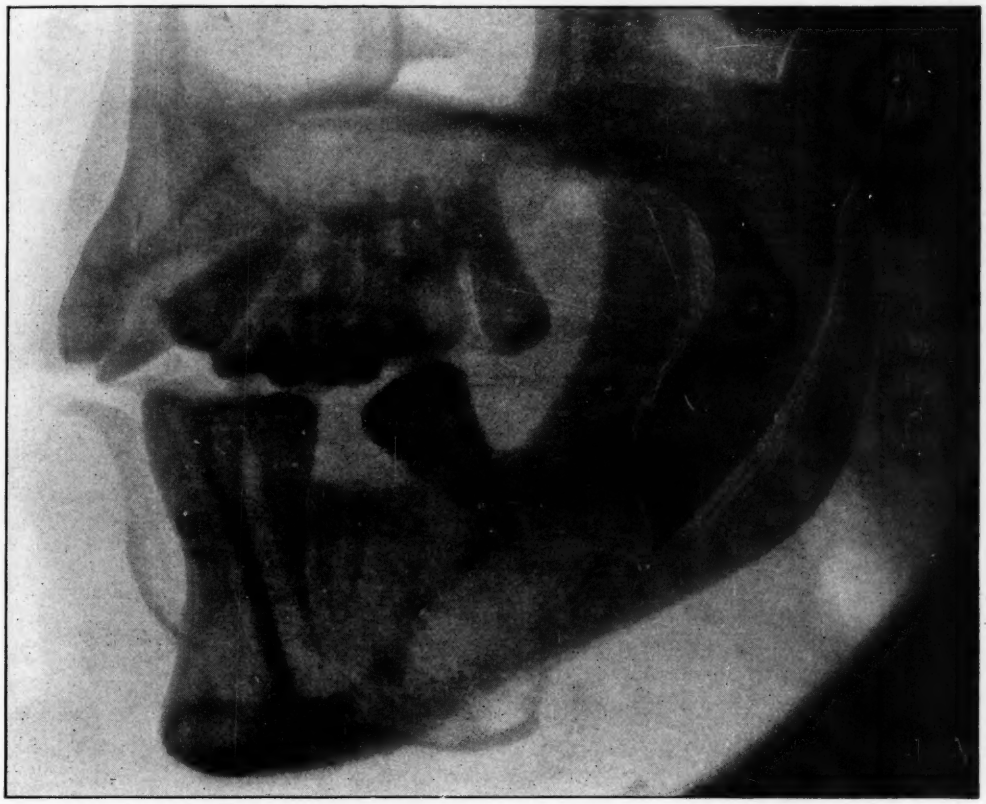

FIG. 194.—SKIAGRAM OF A JAW WHICH HAD BEEN PARTLY DESTROYED BY AN ODONTOME.

earlier than would have been otherwise advisable. The remaining portion of the bone was freely movable; but to obviate the possibility that some contraction might take place, metal caps were cemented over the lower and upper teeth on the right side. To the outer surface of the lower, a strong vertical metal rod was fixed, which rested and moved on a flat vertical metal plate soldered to the outer surface of the upper cap (a similar but movable apparatus is shown in *Figs.* 196 and 197). Hence, the remaining portion of the mandible could not move to the left. The patient was not seen again, as she lived in Northumberland; but she wrote to say that two years later the splint came

away, and that the lower and upper teeth articulated well. In other words, no cicatricial tissue formed to draw the remains of the mandible to the left. This and other similar cases seem to show that if cicatricial tissue cannot contract, in time it disappears, be the explanation what it may.

That the hood embedded in the tissues is not necessarily an irritant to these, is shown in the following case. For a woman, who was edentulous, Mr. Cope removed the lower half of the ascending ramus and half the horizontal ramus of the mandible, the seat of an epithelioma. There being no teeth, a modification of the cap splint could not be used; therefore a splint was inserted having a hood to cover the anterior inferior angle of the remains of the ascending ramus, connected by a metal rod to flanges which passed to the labial and lingual surfaces of the remains of the horizontal ramus, to which they were wired. During the early days following the operation, the patient was able to move her jaw freely. Over six months have now passed, and the whole splint has become buried in the tissues; but the patient remains so comfortable that she refuses to have anything further done.

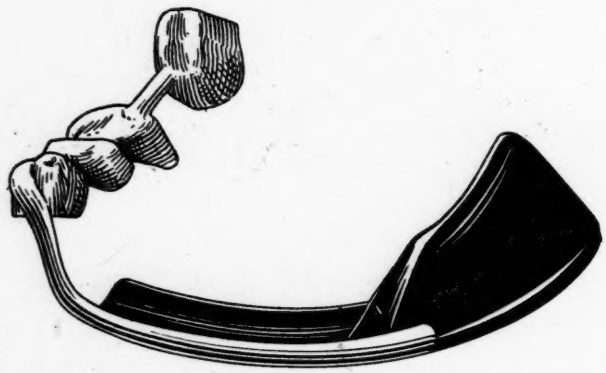

FIG. 195.—COMBINED CAP AND VULCANITE SPLINT USED IN THE CASE SHOWN IN FIG. 194.

It is possible that in this case it would have been well to have made the splint in platinum, the only metal which remains absolutely unaffected by acids, etc., and to have aimed from the first at completely embedding the splint in the tissues. Sir Frederick Eve has used a piece of wire fixed in the end of the bones with success. The method does not prevent facial deformity, due to the falling in of the cutaneous tissues; but when the operation is for the cure of a malignant growth, which in a certain percentage of cases may recur, this is not so important a matter.

Splints which aim at completely preventing facial deformity are necessarily more elaborate, and if a malignant growth recur, will be more in the way than the wire frames used above. *Fig.* 194 shows the skiagram of a jaw largely destroyed by an epithelial odontome, slowly growing, and recurring after many partial removals, over a period of twenty years. In such a case, with total removal no recurrence was to be anticipated. An attempt was therefore made, not only to prevent displacement of the remains of the mandible, but to obtain a depression in the floor of the mouth into which

ultimately a movable apparatus should fit, and lift up the cutaneous tissues. One difficulty in making splints is to be sure of the distances between fixed points; to know exactly where it will be necessary to divide the bone. Such a skiagram as *Fig.* 194 helps very much—it shows the anterior border

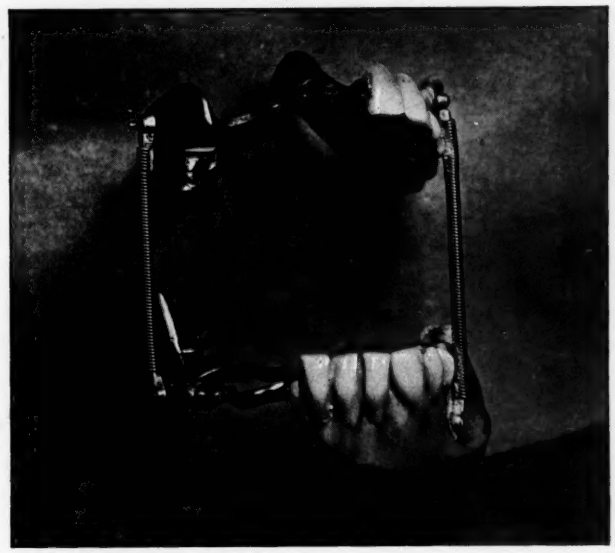

FIG. 196.—APPARATUS USED TO CORRECT THE DEFORMITY IN THE SAME CASE.

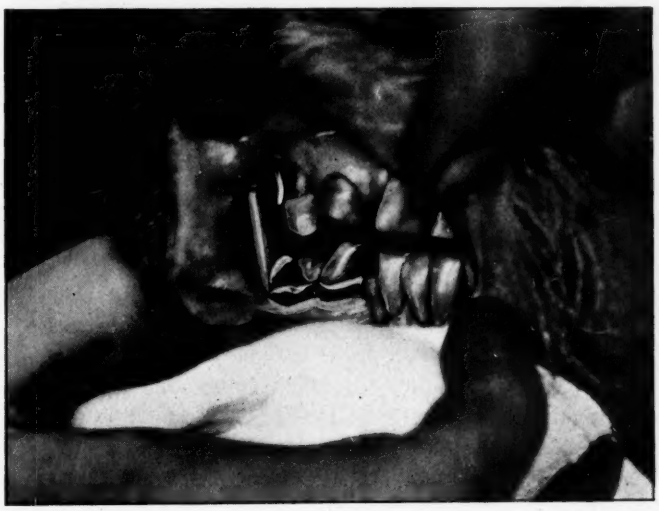

FIG. 197.—THE APPARATUS SHOWN IN FIG. 196, PLACED IN POSITION.

of the ascending ramus to be destroyed, but the posterior intact. A hood would be of no use; but, on the other hand, if the posterior border was left, it would form a resistance to the backward movement of a splint shaped as shown in *Fig.* 195. Here a cap splint is united to a block of vulcanite, shaped to

resemble roughly the body of the jaw, by a gutter of metal to represent and take the place of the lower border of the front portion of the jaw. This splint was inserted at the time Mr. Warren Low operated. It was worn for three months, and on the whole answered well. There was a slight displacement of the remaining portion of the jaw, but it remained freely movable, so that the attachment to the dentures, made subsequently, of a plate and vertical arm (*Figs.* 196 and 197), similar to that used in the previous case, has corrected the deformity.

One deformity which may follow the removal of the anterior portion of the mandible for a malignant growth infiltrating also the base of the tongue, is the disappearance of a chin during the contraction of the scar tissue. Such a result followed in a case of Mr. Pepper's, in which the removal of the whole of the mandible anterior to the molars was necessary. After removal of the bone and a good deal of tissue at the base of the tongue, the

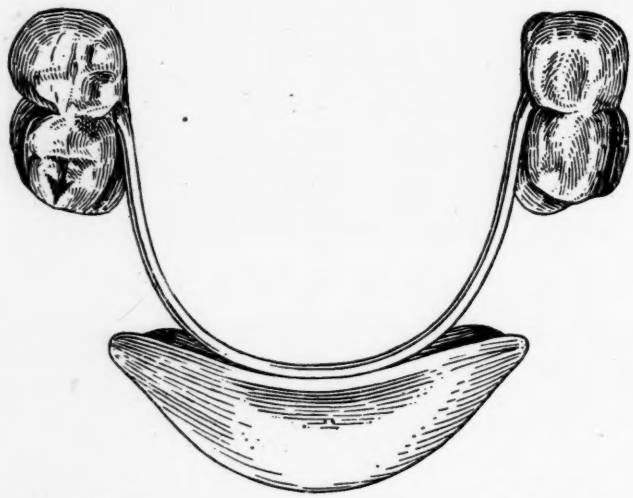

FIG. 198.—SPLINT DESIGNED TO RESTORE THE CONTOUR OF A DESTROYED CHIN.

splint shown in *Fig.* 198 was inserted, and the wound closed. The immediate result was remarkable; but unfortunately the contraction of the scar tissue pulled down the lower lip so that the chin splint failed in its purpose and was removed, a thick wire being soldered to the caps to take its place. Some months later the splint was removed, when it was found that the remaining portions of the mandible were freely movable, there being an almost entire absence of fibrous bands, the chin—or rather the tissues where the chin should have been—being soft and pliable. A denture was then inserted. The patient lived and did his work for about five years, dying of pneumonia a couple of years ago. He had, before operation, an exceptionally well formed chin, giving him a notably manly look; hence the difference in appearance afterwards, in the absence of a chin, was very marked. Thus the problem of producing a pouch into which a movable appliance would fit and lift up the skin to produce a chin, seems one worth solving in such cases. Probably it was the fibrous tissue forming at the base of the tongue and drawing

the skin on to the hyoid bone which here caused the failure. For a similar case a splint was made with a plate to pass between the skin and this bone, which, it was hoped, might have prevented this result; but the patient in the end refused operation. The pocket produced by this plate would naturally require the insertion, for a time, of a tube for drainage.

It must be admitted that in some cases curiously little displacement of the remains of the mandible follows loss of a considerable portion of bone, even when no preventive treatment is adopted. *Fig.* 199 shows such a case, the remaining teeth articulating almost normally. This was a patient admitted to a London hospital about three weeks after receiving a gunshot injury. The mouth was foul and the breath extremely offensive. Into the

FIG. 199.—FROM A CASE OF GUNSHOT INJURY. To illustrate the comparative absence of deformity which sometimes occurs after considerable destruction of the mandible.

inner surface of the cheek a thick wire was found sticking, which on investigation proved to be part of a suture connecting two large sequestra. The removal of these and several smaller ones, leaving the space shown in *Fig.* 200, was followed by rapid improvement. Nevertheless, when this skiagram was taken it was too early to be sure of the absence of displacement, and the patient, since his discharge, has not been seen.

Maxilla.—The use of a splint after removal of the maxilla, whether by injury or operation, has three objects: to prevent facial deformity by obviating cicatricial contraction; to keep the skin-flaps at rest while they are uniting;

and to relieve the patient of pain whilst the cavity is being plugged or syringed. A movable splint may prevent deformity, but being never really at rest it rather increases than diminishes the coincident discomfort. Moreover, being removable, when it does produce irritation, and even pain, it may be and often is impossible to persuade the patient to continue to wear it.

If teeth be present in the remaining maxilla, or portion of maxilla, by a modification of the cap splint it is fortunately possible to design a fixed apparatus which meets all requirements, and the use of which is strenuously advocated in suitable cases.

FIG. 200.—ANOTHER VIEW OF THE CASE SHOWN IN FIG. 199, AFTER THE REMOVAL OF SEQUESTRA.

A metal cap to cover the remaining teeth is prepared, in exactly the same way as for the cap splint. The plate is continued over the portion of the palate to be left (*Fig.* 201), or better, as made in recent cases, since it is more easily cleansed, from the cap two or three bars pass across the palate to join a median band running antero-posteriorly, and having its outer or free edge extending outwards over the margin of the remains of the hard palate. The whole of this, caps and bars, can be made by the new casting process in one piece. A vertical metal plate is then shaped to correspond roughly with the facial surface of the bone lost—or to be removed—and is attached to the caps and frame.

The vertical plate is shaped to a model obtained from a skull of about the same size. The depth of the plate will vary with that of the bone lost, being naturally deeper if the orbital plate is to be removed. The splint is cemented in place after the bone has been removed and the bleeding arrested. The orbital and nasal aspects of the wound are not covered, and can be clearly seen. The cavity is then plugged in the usual way, but behind the plate, and the skin flaps are replaced.

When any discharge from the wound has ceased, a metal palate, prepared beforehand, is fixed inside the splint to take the place of that removed. This, provided the soft palate remains, shuts the nasal from the oral cavity, and allows the patient to eat and drink without the food entering the former, an advantage much appreciated. In the case of an officer, a patient of Mr. Wilson, whose maxilla was smashed by a bullet entering the back of the neck, just missing the spine, and emerging on the face, the patient much appreciated the advantage of the apparatus in enabling him to smoke a cigarette.

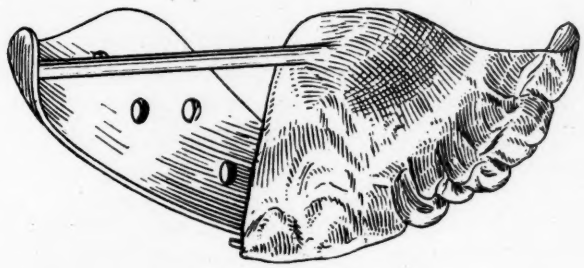

FIG. 201.—MODIFIED CAP SPLINT FOR EMPLOYMENT AFTER BONE HAS BEEN LOST OR REMOVED FROM THE MAXILLA.

It is essential that all edges should be rounded, and curl inwards, since this splint should remain in place for several months, in fact till all chance of cicatricial contraction has passed; otherwise irritation may be caused, needing its premature removal. When removed, an obturator bearing teeth, etc., is made and inserted in the usual way. When no such splint is used, the obturator is inserted much earlier. This causes a good deal of trouble; the patient is usually hypersensitive, and the worry both to him and the dentist is very great. Commonly, a new one has to be made after a short period, for the contraction of the tissues still goes on.

When the growth is malignant there is always the risk of recurrence, but the splint can be removed if need be; and in any case a movable obturator would probably have been inserted before the recurrence commenced. The writer well remembers such a case, where he had to cut the obturator as the growth grew, and, to speak candidly, to bear the reproaches caused by the pain, since it was not expedient to tell the patient its real cause.

When it is necessary to remove the floor of the orbit the resulting deformity is greater than when this can be left. Hence, in such cases, the use of this splint is especially indicated. Then the vertical plate must be carried high up into the wound above the level of the mucous membrane of the mouth and so be in contact with raw tissue. In one such case, undertaken by Dr. Austen

for Mr. Gask, the granulations sprouted through the perforations made in this plate for drainage purposes, and developed into tissue of a fibrous nature, rendering removal of the splint difficult. In a recent case, these perforations have been omitted without apparent detriment. Indeed, the result is particularly pleasing, since the splint has entirely prevented that sinking in of the tissues at the level of the floor of the orbit which almost always occurs after this operation if no splint be used. No case could better illustrate the importance of preventing deformity if it be possible. The patient, a young officer, appears to have forgotten, even if he ever fully appreciated, the danger to his life of a sarcomatous growth from which he has escaped, and is apparently, perhaps quite naturally, solely concerned with regaining clearness of speech and his normal appearance.

When the bone has been lost as a result of a gunshot injury, commonly a plastic operation is necessary to close the skin wound. If possible, it is advisable that the splint be fixed before this is performed, since it restores the contour of the face, and the size of the flaps can be better judged. Even if the plastic operation has been performed, it is preferable to insert such a splint early, and wait several months for the movable apparatus. For, apart from the prevention of cicatricial contraction, unless the orbicularis oris has a mechanical resistance over which to draw the lip, it degenerates, and the mouth will not be symmetrical. This is especially true if, unfortunately, the flap cannot be made as ample as it should be.

The scope of this paper is not intended to cover the forms of the appliances used after the removal of the splints herein described, or when they have not been employed. But we do not desire to convey the impression that nothing can be done to alleviate the condition of those who suffer from facial deformity, with mal-occlusions of the teeth, the result of failure or absence of treatment. That is far from being the case. Nevertheless, the result attained can never equal that in which deformity has been prevented. No appliance can ever equal natural teeth in normal occlusion.

In proportion to the realization of this truth will grow the appreciation of splints and the desire to use them.

PERFORATING WOUNDS OF THE RECTUM.

By H. J. WARING, London.

Perforating wounds of the rectum may be caused when a patient falls, striking the perineum upon a sharp or blunt instrument, such as the long handle of a brush, or an iron spike with a narrow and pointed extremity, or are due to a violent thrust of an animal's pointed horn, or a stick or umbrella. Such injuries are not common, but recently two patients have been admitted to my wards at St. Bartholomew's Hospital, in each of whom a perforation of the rectum had followed the forcible passage of a blunt body per anum. In the first case the perforating body was the handle of a sweeping broom, and in the second the conical end of an iron bar three feet long.

The important facts in the clinical accounts of these two patients are abstracted and detailed below.

Case 1.—On June 7, 1913, at 5 p.m., a youth, age 17, a warehouse porter by occupation, jumped down from a shop counter and alighted upon a broom-handle which was leaning against the counter. The extremity of the broom-handle struck him in the anal region and was stated to have penetrated about one inch. He experienced severe pain in this region, and fainted. At 7.30 p.m. he was brought to the hospital in a police ambulance, and admitted to an observation ward. On examination, two contused wounds each about half an inch in length were found on the posterior margin of the anus. Nothing abnormal was discovered in the rectum, no laceration was detected, and there was no evidence of rectal hæmorrhage. The abdomen was soft, not distended, and there was no tenderness. The patient was in no distress, the temperature was 98·6°, the pulse 84, the respiration 20. The diagnosis was made of contused wounds of the anal region, and the patient was detained in an observation ward. He slept well, but in the morning complained of severe abdominal pain immediately below the umbilicus, and later vomited, the ejecta being stomach contents and containing no blood. The bowels were slightly opened, and a small quantity of blood-stained mucus was also passed. The patient was then transferred to a surgical ward. When seen by me at 11 a.m. he looked ill, with flushed cheeks and shallow breathing. The abdomen was slightly distended, and pain was referred to the lower half, especially in the hypogastrium. There was distinct rigidity of the abdominal muscles, most marked below, whilst the movements of respiration were limited. The liver dullness was normal. The temperature was 99·8°, the pulse 120, and the leucocytosis 13,000. The diagnosis was made of acute peritonitis consequent upon perforation of the rectum, and immediate operation recommended. Some delay was experienced in obtaining the consent of the patient's parents, but at 12.30 p.m. the operation was carried out. The patient was anæsthetized with ether, and an incision a little to the left of the middle line made in the hypogastrium. The peritoneal cavity was found to contain a quantity of thin purulent matter, and in the pelvis in addition were found some masses of formed fæces and an apple pip. The fæcal matter was removed, the pelvic cavity and field of operation were sponged dry, and the patient was placed in the raised pelvic position. The pelvic colon and rectum were investigated, and a large lacerated wound, circular in shape and about an inch in diameter, was seen in the anterior wall of the rectum at the bottom of the rectovesical pouch, close to the bladder (*Fig.* 202 A).

The lumen of the rectum was easily visible through the laceration. The margins of the wound were sponged clean, swabbed with tincture of iodine, and then sutured by the insertion of three tiers of superimposed sutures of chromicized catgut No. 2. The field of operation was again sponged dry, and the pelvic colon and small intestine were investigated. A lacerated wound one and a half inches in length was discovered in the dependent portion of the pelvic colon (*Fig.* 202 B), about six inches above the wound in the rectum. This involved the serous and muscular coats, but did not extend through the mucous membrane. It was closed by a series of interrupted sutures of catgut introduced by Lembert's method.

All the exposed coils of small intestine were seen to be acutely inflamed. The pelvis was lowered, and then the peritoneal cavity thoroughly irrigated by normal saline. The wound in the parietal abdominal wall was partially closed, the lower portion being left unsutured, and a red rubber drainage-tube of large calibre passed to the bottom of the pelvis. The patient was nursed in the sitting posture and a continuous rectal saline given. The after-history was uneventful, with the exception that for some days the patient had incontinence of fæces; there was also a purulent discharge from the drainage tube, but no fæcal material. The tube was soon changed for one of smaller calibre, and then gradually shortened. On July 16 he was quite convalescent and the wound had practically closed. He was discharged from the hospital, and when seen a few weeks later was quite well.

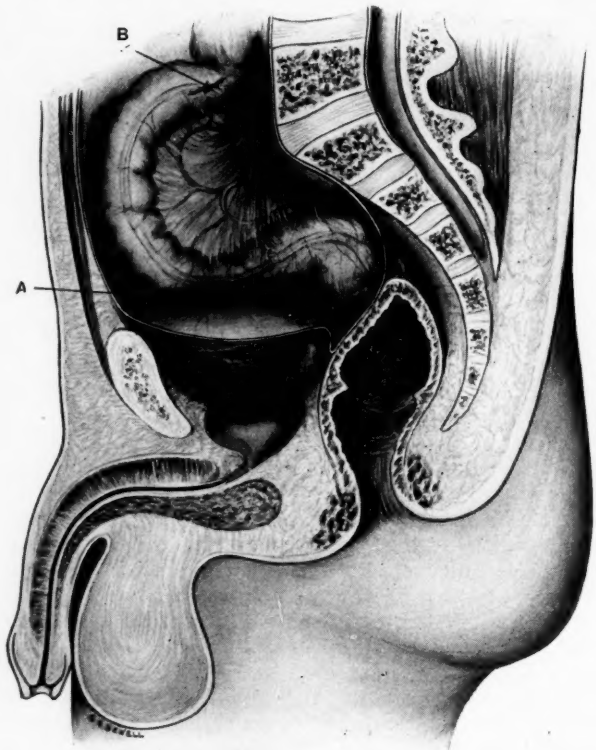

FIG. 202.—WOUNDS OF THE PELVIC COLON AND RECTUM.
A. Perforating wound of the anterior wall of the rectum. B. Wound involving the peritoneal and muscular coats of the pelvic colon.

Case 2.—A schoolboy, age 9, was playing a game of hide and seek at 5 p.m. on Nov. 15, 1913, when he fell upon a blunt iron spike, one end of which passed through the anus and into the rectum. It was thought that the spike passed inwards for four or five inches. The boy removed it himself, and beyond experiencing severe pain at the time of the accident, does not appear to have suffered from shock. He went home, but soon had abdominal pains which increased in severity, and at 10 p.m. he was brought to the hospital. On examination, the patient looked ill and flushed, the temperature was 101·4°, the pulse 120, and the respiration 28. Examination of the anus and rectum showed nothing abnormal beyond slight bruising of the margin of the anus. No laceration of the rectal wall could be detected, and no blood was seen. The abdomen was almost motionless in the lower half, whilst the upper half moved poorly. There was marked rigidity of the abdominal walls, and tenderness in the left iliac fossa. The diagnosis was made of acute peritonitis

following perforation of the rectum. At 10.45 p.m. my colleague, Mr. Gordon Watson, operated. The patient was placed in the dorsal posture with the pelvis raised. A median incision in the hypogastrium was made, and the pelvic cavity and contents explored. The posterior aspect of the base of the bladder was found to be bruised, and in the floor of the pelvis on the left side and close to the vesico-rectal reflection of peritoneum, a lacerated wound half an inch in length was found which communicated with the lumen of the rectum. No rectal contents were found in the peritoneal cavity. The region of the perforation was sponged dry and the margins united by two superimposed tiers of sutures of chromicized catgut. The field of operation was then well sponged with saline solution, the intestine replaced in the pelvis, and the parietal wound closed. A tube was passed into the rectum and two ounces of olive oil introduced. The next morning at 11 a.m. the patient was very well, the temperature being 100·4°, the pulse 120, and the respiration 28. Half an hour later the patient suddenly collapsed, the temperature being 102·8°, the pulse 140, and the respiration 56. On examination the patient was found to have 'massive collapse' of the left lung. He was treated by stimulants, injections, etc., and ultimately recovered. As regards the injury to the rectum nothing abnormal developed, and the boy left the hospital on Dec. 5, quite convalescent.

These two cases emphasize the importance of immediate operation in cases where a perforation of the rectal wall is suspected. In the first case, perforation was thought to have been excluded by the house surgeon, owing to the absence of abdominal symptoms and the non-detection of any injury by an examination of the rectum. I suppose that at the time of the reception of the injury the rectum was quite empty, and that during the night intestinal contents passed into the rectum and thence through the lacerated wound into the pelvic cavity. Certainly, when I operated there were several large masses of formed fæces at the bottom of the pelvis. Matters in this case were made worse by the delay which was experienced in obtaining the consent of the patient's parents to the performance of an operation. Fortunately the final result was satisfactory. A point of interest was the continuous irrigation of the peritoneal cavity for half an hour with hot normal saline solution. Some surgeons strongly deprecate such a procedure, but for many years it has been my invariable practice in cases of general peritonitis to have recourse to this method of cleansing the peritoneal cavity. My results have been excellent, very much better than when I merely swabbed or sponged everything dry.

Case 2 is chiefly of interest on account of the early period at which the perforation was closed, and the occurrence of 'massive collapse' of the lung, the cause of which appeared to be doubtful.

A NOTE ON THE ABUSES AND DANGERS OF DRAINAGE TUBES.

WITH SPECIAL REFERENCE TO THE DANGER OF SERIOUS HÆMORRHAGE FROM THE EROSION OF LARGE ARTERIES.

By Major G. GREY TURNER, R.A.M.C.(T.)

For some time I have been impressed with the abuses connected with drainage tubes; and this has been accentuated as the result of twelve months' experience of war surgery.

Drainage tubes are valuable aids in surgery, and the freedom with which they are used at the present time is largely due to the fact that they are recommended in all the Memoranda published on the treatment of wounds in war. This is all the more reason why care should be exercised in their routine employment.

A tube can only actually 'drain' some pre-existing cavity such as an empyema, or a distended gall-bladder, or an abscess with thick walls. Apart from that, it may keep a track patent between some deeply situated septic focus, or much-damaged tissue, and the surface of the body, and along this track exudations of various sorts may safely find their way to the surface. For the former purpose it is necessary to have tubes of such a calibre that they will not easily become blocked by the organization of blood or the coagulation of discharge, and their walls require to be sufficiently rigid to prevent their being pressed together by the tissues. For the latter purpose much smaller and softer tubes will suffice.

A common fault is the employment of tubes of a colossal size, and I have on more than one occasion removed from the limbs tubes of the largest size manufactured—far and away out of all proportion to the necessities of the particular case. Such a tube certainly keeps a track open in the tissues, but it keeps an unnecessarily big track and for too long a time. I should say that for the purpose of military surgery it is never necessary to use tubes larger than the diameter of an ordinary adult little finger.

Tubes are often allowed to remain in wounds far too long. Of course the time must depend on the necessities of the particular case, and if a drainage tube is employed to communicate between some septic focus, such for instance as a foreign body or necrosed bone, and the surface, it may require to be kept *in situ* until either the one or the other is removed. But when it is simply a question of providing an exit for the discharges from an infected track or a deep septic wound, then it will scarcely ever be necessary to retain it longer than from fourteen to twenty-one days. In civil practice I have several times seen a track actually kept open by the persistent use of a drainage tube, what was supposed to be an intractable sinus immediately closing after its removal. Very often a counter-opening will do away with the necessity of a very long tube, and will be more efficient.

Another abuse is illustrated by a reference to suppuration in the hand or foot, where I have seen cases simply riddled with small drainage tubes, which the patients tell me have been most carefully readjusted day by day. I have in mind one case in particular, in which an R.A.M.C. man was suffering from the effects of a shrapnel wound of the foot. A fine tube was intricately passed in various directions, and as far as I could see without serving any useful purpose; at all events, as soon as it was removed the multiple apertures healed.

The principal danger to which I am anxious to draw attention is the ulceration and perforation of blood-vessels by drainage tubes. When this occurs, it is probably always due to a combination of sepsis and pressure. My attention was first directed to the possibility of serious ulceration occurring in this way by the case of a man whose lower jaw was removed for cancer. A large catheter was passed through the nose into the pharynx for feeding purposes, and was allowed to remain until the eighth day, when the patient died of septic pneumonia. At the necropsy I secured the specimen from which *Fig.* 203 has been made. An ulcer had been produced, laying bare the posterior cartilage of the larynx and leading to its necrosis.

FIG. 203.—ULCERATION OF THE PHARYNX WITH NECROSIS OF THE POSTERIOR LARYNGEAL CARTILAGE, the result of pressure by a catheter used for nasal feeding after excision of the lower jaw. The catheter was in situ for eight days, when death took place as the result of septic pneumonia. The illustration shows the posterior aspect of the pharynx with the larynx and trachea. On the left side of the pharynx there is a long channel-shaped ulcer in the position where the end of the catheter lay. The latter is also shown by the side of the specimen, the perforated extremity lying just opposite the ulcerated area which it had produced. The catheter was made of hard, unyielding rubber.

Another illustration of the power of a foreign body like a drainage tube to produce destruction of the neighbouring tissues, or rather an illustration of the recession of the tissues before the presence of a firm foreign body, is

illustrated by the specimen of which *Fig.* 204 is a photograph. In that case a tube had been introduced between the ribs for the drainage of an empyema, and had been allowed to remain for twelve months. Both ribs were grooved to the exact size of the tube, the circular hole being completed by their union around it.

Should the drainage tube be in the neighbourhood of a large artery, the same process is likely to occur, and the following are brief notes of two cases in which the femoral artery was eroded by the pressure of a drainage tube, leading to serious hæmorrhage :—

Case 1.—The patient, E. B. (Reg. No. 1309), age 15, was admitted to the Newcastle Infirmary on October 8, 1907, suffering from lacerated wounds of the left thigh. They became grossly infected, and had to be opened up. Two rubber drainage tubes were introduced from the inner side across the thigh to the wound on the outer side. The temperature came down and, with the exception of a very foul-smelling discharge, the wounds were healing satisfactorily until Oct. 15, when the

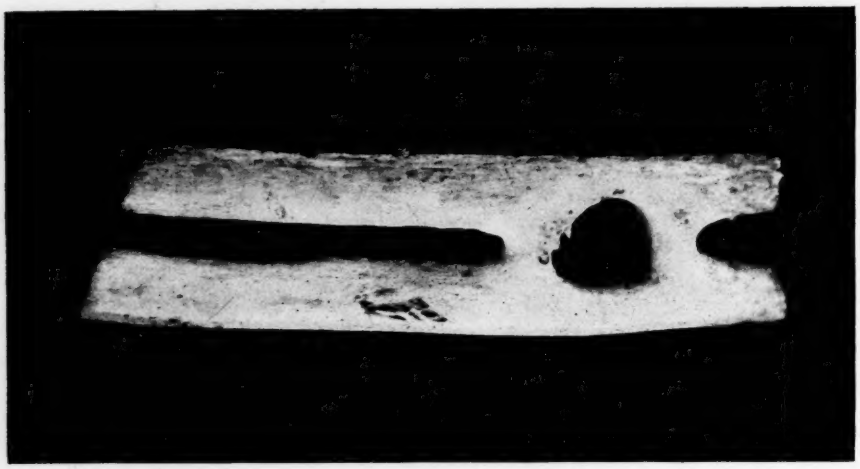

FIG. 204.—PORTIONS OF TWO RIBS GROOVED AND UNITED.—The result of wearing a drainage tube for a year in a case of chronic empyema.

temperature went up to 100·8°. By Oct. 17 the wounds were much cleaner, and the boy appeared to be doing well. Without any warning, on the evening of the 18th there was sudden and exceedingly severe hæmorrhage, which had to be dealt with at once. A length of the popliteal artery, about three inches in extent, was found to be exposed in the wound, and there was a circular hole in its centre about one-eighth of an inch in diameter, exactly in the position where one of the drainage tubes had lain. The portion of artery with the ulceration is shown in *Fig.* 205. The thigh was amputated, the patient making a good recovery.

Case 2.—In a boy (Reg. No. 824) with necrosis of the femur there was profuse secondary hæmorrhage ten days after a popliteal abscess had been opened and drained with a tube. The artery was tied above the site of ulceration, but gangrene supervened, necessitating amputation of the thigh, the boy ultimately dying of pyæmia.

I have also seen several cases in which smaller arteries have been opened, and at least one case of appendicitis where, owing to this cause, there was fatal hæmorrhage from the external iliac.

There can be no doubt this is a serious possibility. I have just removed a large tube from the thigh of a soldier who sustained a compound fracture, the result of a gunshot wound, and who was admitted under my care eight weeks afterwards. The tube was passed right across the limb at the junction of the middle and lower third, and the femoral artery probably only owed its immunity to the fact that it was out of the way. The tube was immediately removed, and there has fortunately been no hæmorrhage, though this is exactly the class of case in which this accident is apt to occur.

My experience is not singular, and the matter has been made the subject of experimental research by Weissenbach and Bertier.[1] Their enquiry was initiated because of a case of appendicitis in which a rubber tube ulcerated into the external iliac artery, leading to the death of the patient. As a result of their experiments the authors conclude:—

1. That simple contact, no matter how prolonged, of a sterile drainage tube with a healthy artery did not cause ulceration.
2. That if traumatic ulceration by actual necrosis from contact of an aseptic foreign body was possible, it was so only under exceptional conditions —as in one experiment, where the thread fixing the tube wore its way through the vessel wall.
3. That the rôle of infection in so-called traumatic ulceration was of great importance.
4. That the drain played the part of localizer of the infection in relation to the artery, the rupture being the mechanical consequence of the acute localized arteritis.
5. That it was necessary for the contact of the artery and the drain to be quite close.
6. That in an infected area it was never advisable to leave a drainage tube in contact with an artery for more than two, or at most three, days.

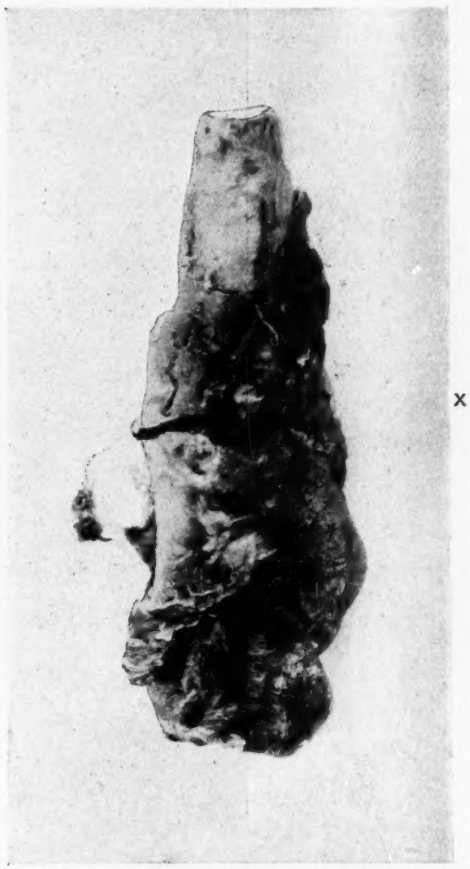

FIG. 205.—A PORTION OF THE POPLITEAL ARTERY SHOWING A PERFORATION.—The result of ulceration from the pressure of a drainage tube. The X is placed opposite the perforation.

With this advice I certainly agree, and even should it be considered necessary to place a tube near a large artery, it must not be pressed against

it by gauze packing, nor must it be fixed by a stitch, as is sometimes done.

Some may ask what can best take the place of a tube where it is felt necessary to drain in the neighbourhood of a large vessel. I would draw attention to the value of drains made of rubber sheeting, which can be folded to various sizes, a very useful size being made by taking a strip six inches long and one inch broad, doubling it once over lengthwise, and stitching it along the edge. These can be boiled and used more than once, if necessary. I

FIG. 206.—SEQUESTRUM FROM THE FEMUR, TOGETHER WITH A PORTION OF DRAINAGE TUBE SIX INCHES LONG.
The latter was lost in the wound for several months, and amputation had been contemplated.

invariably employ these rubber strips where it is necessary to make drainage across a limb or anywhere in the neighbourhood of large vessels, and I have found them most satisfactory.

Lastly, there is the possibility of losing a drainage tube in the tissues. This was recognized and mentioned by Ambrose Paré in connection with the use of tents. Writing in 1553 on the treatment of wounds of the chest, he says :—

> . . . and put in each wound a tent with a large head, fastened with a thread, lest on inspiration it should be drawn into the chest, which has happened to surgeons to the detriment of the poor wounded; for being fallen in you cannot get them out; and then they beget corruption, being foreign bodies.

That the loss of a drainage tube from the want of a pin or a stitch* is a very real danger I have every reason to know. *Fig.* 206 shows a tube which disappeared in this way. The patient was a lad of 18, suffering from necrosis of the femur, and the tube had been in the limb for several months at the time he came under my care. The accident still happens, for a similar case was reported from the 2nd Eastern General Hospital, Brighton, quite recently :—

> A man was admitted with a large sinus of the arm due to a bullet wound. It showed no tendency to heal, and an *x*-ray plate revealed a large drainage tube, about five inches long, which had slipped right into the wound. Its presence had not previously been suspected.[2]

It is not out of place to add a word on the sterilization of drainage tubing. I feel this the more necessary because at one time I discovered that my tubes were simply being boiled and stored in sterile water, the stock being re-sterilized and the water changed once weekly! Rubber tubes should either be freshly boiled for ten minutes immediately before use, or should be boiled and stored in a reliable antiseptic such as 1–20 carbolic or 1–1000 perchloride of mercury, which should be changed at least once every week. Theodor Kocher, one of the greatest pioneers in the field of aseptic surgery, advises that drainage tubes should be "boiled for ten minutes in 1–1000 perchloride, in which solution they are retained and from which they are lifted directly previous to use."[3]

REFERENCES.

[1] *Arch. Gén. de Chir.* 1912, July 25 ; Epitome, *Brit. Med. Jour.*, 1912, Nov. 23.
[2] *Brit. Med. Jour.*, 1915, i, 909.
[3] *Text-book of Operative Surgery*, Third English Edition, p. 9.

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* By the same process by which a tube may cause ulceration and perforation of a blood-vessel, an unabsorbable stitch may cut its way out through the tissues, thus making it possible for a tube so fixed to slip into the wound and get lost. For this reason it is always necessary to use a safety-pin in addition to the stitch which is sometimes employed to prevent a tube slipping *out* of the wound.

THE SURGERY OF THE ENLARGED PROSTATE.

By GRAHAM SIMPSON, Sheffield.

The following remarks are based on an analysis of the cases of enlargement of the prostate which have occurred in my private practice; I have not included any cases seen by me in the last two years, as the analysis has been made chiefly from the point of view of the after-results.

The object of this paper is to demonstrate that, just as in operations for appendicitis or for carcinoma, the results depend very largely on the stage of the disease at which the patients are sent to the surgeon. It is a plea for early operation in cases of enlarged prostate.

I do not contend that all the late cases do badly; one man had suffered from complete retention for ten years, and yet did admirably; but all the cases that resulted badly had shown symptoms of urinary trouble for a long time, and the early cases invariably made a good recovery.

The question I wish to put is this: Supposing the surgeon sees a man suffering from slight dysuria (nocturnal frequency, loss of power in the stream, and perhaps a little pain on micturition), and finds that he has an enlarged prostate; should he advise that man to have his prostate removed, and is he justified in actually urging it?

Most of the modern surgical text-books either do not give one a clear lead, or they mention various methods of palliative treatment which they imply should be first tried.

The argument in favour of operation at this stage seems to me to be as follows: The early operation has a very low mortality-rate, probably under 5 per cent, and possibly a good deal less (I presume that the patient's lungs and heart are moderately sound); the inconvenience of lying in bed for two or three weeks is not more than most people would cheerfully consent to for an abdominal operation, such as gastro-enterostomy; if palliative treatment is adopted, no surgeon on earth can say that an operation will not be necessary later for retention, cystitis, or hæmaturia, and it is fairly certain that the mortality is then distinctly higher.

The argument against early operation is that many patients go on for years with occasional catheterization, and live in 'comparative comfort': that it is not of much use to inform the patient that the mortality is only 2 per cent unless you can assure him that he will not be one of those two: and that operation can always be performed later if this should be found necessary.

The answer to the question seems to me to depend on the after-results of the operation. Does an examination of the patient some time after the operation show that: (1) He can make a normal stream; (2) He has no increased frequency of micturition; (3) He has no pain on micturition; (4) He has had no hæmaturia; (5) He has perfect control of the bladder?

From an investigation of my own cases, I am inclined to say that the results of an early removal of the prostate, before the onset of retention or cystitis, are perfect as regards all except No. 2, and show a very great improvement in that respect. In other words, I believe the surgeon can conscientiously say to the patient in the early stage of the disease, "If you have your prostate removed now, you will run a very slight risk; and, if the operation is successful, you will have absolutely normal micturition, except that you may have to get up once or twice in the night."

Several of my patients had heard of the operation, and had asked their doctor, years before I saw them, if he advised them to have it done; they were told that it would be better to wait, as it could always be done later if complications ensued. This, I feel sure, was due to the fact that the medical man did not realize the discomfort of having something amiss with the water-works. nor the excellent result of early operation; in one of these cases, the patient had taken a great interest in public life, but had felt obliged to give up his position, and active work in his business, on account of the irksomeness of always having to use a catheter; he did perfectly well after the operation, but felt that ten years of his life had been sacrificed by not having his prostate removed earlier; so far from having lived in 'comparative comfort,' he said that he had lived in superlative discomfort. The passing of a catheter is a disgusting affair to a layman at the best; it becomes a torture when the urethra is inflamed and bleeds at every attempt.

Out of the 36 cases that I have seen in consultation, 26 were operated on. Of the 10 not operated on by me: 2 refused to have any operation; 3 were advised against operation (they were all bedridden, suffered from severe bronchitis, and had irregular, intermittent pulses); 2 were obviously malignant; 2 died of uræmia before any operation was done; 1 was operated on by another surgeon and did very well.

Of the 26 operated on by me: 2 died as a result of the operation (a mortality of 8 per cent); 13 are quite well after varying periods (1 for six years, 2 for four years, 3 for three years, and the rest for more than two years); 4 have died since; 2 were quite well for some years after the operation, but have now been lost sight of; 5 have not been traced.

The two that died from the operation were both cases of retention which had lasted over a week, and they had both suffered from urinary symptoms for many years. One undoubtedly died of uræmia, nineteen days after the operation. The other died suddenly fourteen days after, possibly from pulmonary embolism, but more probably from uræmia also. They show the danger of waiting until retention is established.

Of the four that have died since the operation, one died of what was thought to be cancer of the stomach four years after; he had no return of the urinary symptoms. Another who had locomotor ataxy at the time of the operation, died four years later without any return of the urinary symptoms. Another did well for two years, and then contracted a *Bacillus coli* infection of the bladder to which he succumbed in a few days. The last died six months after the operation, and I have not been able to get any accurate news of his last illness.

The remaining thirteen cases whom I have been able to trace all answered the following questions :—

1. Have you any pain on passing water now ? They all answered 'No.'

2. Can you pass your water now without any difficulty ? 'Yes' in every case.

3. Do you ever see any blood in your urine now ? 'No' in every case.

4. How many times do you get up at night to pass water now ? 'Not at all' from two ; 'once' from two ; 'once or twice' from the others.

5. Is the water clear now ? They all answered 'Yes.'

6. Do you suffer from headache, thirst, or pain in the loins ? Four stated they had 'lumbago' ; the others answered 'No.'

7. Are you glad you had the operation done ? They all answered 'Yes,' and seemed very grateful ; one added that ' otherwise he would have joined the majority long ago;' another said that he was 'exceeding glad' ;—he was a parson.

Thus, of 26 prostatectomies, 2 died as a direct result of the operation 5 have not been traced ; 4 have died since, and in three of these it is known that no recurrence of the urinary symptoms took place ; 2 remained well for some years, and were then lost to view ; of the remaining 13 I think it is not too much to say that the result is excellent, and justifies our urging the operation in early cases.

SHORT NOTES OF RARE OR OBSCURE CASES.

FOUR CASES OF PERSISTING INFECTION OF THE BRAIN FOLLOWING INJURY BY PROJECTILES.

By C. HAMILTON WHITEFORD, Plymouth.

The cases here recorded were operated upon by the writer in the Military Hospital, Devonport.

1.—**Intracerebral Sinus. Encephalitis. Decompression. Death.**

The patient was seen four weeks after the injury. In the upper right parietal region was a sinus which extended into the brain, at right angles to the cortex, to a depth of two inches. The only symptom was severe headache. A very free decompression was performed, and the dura mater incised, the intracranial tension being extreme. Two rubber tubes, with lateral openings, were placed in the sinus.

Drainage failed, hemiplegia supervened, aspiration of the lateral ventricle produced no improvement, and death occurred nine days after operation.

The autopsy showed no collection of pus, only a diffuse encephalitis, the brain, in the infected area, being almost diffluent. [*Ref. No.* 102.]

2.—**Intracerebral Abscess. Extension into Lateral Ventricle. Decompression. Death.**

The patient had been wounded three months previously, and had lately become maniacal. In the upper right parietal region were two small sinuses leading into the brain. A large decompression was performed. On incising the dura mater, much pus, mingled with a large quantity of cerebrospinal fluid, poured out. The right side of the brain formed practically one large abscess cavity. Death occurred four hours after operation. [*Ref. No.* 103.]

3.—**Subcortical Sinus. Decompression, with Laying Open of the Sinus. Recovery.**

The patient was seen five weeks after the injury, which had produced immediate incomplete right hemiplegia, from which partial recovery had taken place.

From near the middle line, in the left upper parietal region, a sinus passed downwards and forwards for $3\frac{1}{2}$ in., in the left motor area, $\frac{1}{2}$ in. beneath the cortex. The dura mater overlying this track was exposed by removing an area of bone 4 by $1\frac{1}{2}$ in. A director was passed into the sinus, and the dura mater and brain between the surface and the director were incised throughout

the length of the sinus. A rubber tube, 5 in. in length, with lateral openings, was placed between the incised cortex and the scalp, which was sutured, except where the ends of the tube projected.

During the first two weeks large quantities of pus and brain sloughs were removed from beneath the scalp by irrigation. During convalescence two cerebral fungi formed in the unsutured scalp areas, and were removed.

The condition, four months after decompression and drainage, was as follows: The right arm is partly paralyzed, the shoulder can be raised, and there is slight power of grasping large objects. The right leg is weak, but can be brought slowly forward in walking, and the patient can stand without support. There is neither aphasia nor facial paralysis. Sight and intellect are perfect. There is no hernia, and the scalp is firmly healed. [*Ref. No.* 104.]

4.—**Extradural Abscess. Drainage. Recovery.**

Four weeks prior to admission, the patient had been shot in the left temple and rendered unconscious for half an hour.

The man appeared quite well, but a sinus was present one inch above the left ear. From this sinus pus flowed freely, averaging two ounces in twenty-four hours. A probe passed upwards and forwards for 1½ in., impinging on an edge of bone, but did not enter the skull. The skin area surrounding the sinus was slightly tender, and an operation scar of 1½ in. passed from the sinus upwards. The skiagram showed a fissured fracture of the skull in the left upper temporal region. No foreign body was demonstrated.

Operation was decided on, there being no obvious extracranial origin for the large amount of pus which was produced daily. While awaiting operation, the flow of pus suddenly almost ceased, with development of intense headache, and immediate operation became imperative.

Beneath the sinus was found an area of bone, the shape and size of a penny depressed one-twelfth of an inch below the adjacent skull, in which were two fissured fractures, the bone surrounding these fissures being inflamed and softened. No pus was seen, and no opening in the bone was visible. The skull above the depressed area was opened with a gouge, and one and a half ounces of thick pus poured out in a pulsating stream. The abscess cavity passed upwards and inwards between the dura mater and the highest portion of the frontal bone nearly to the mid-line. More bone was removed, and drainage instituted by a bundle of looped silkworm gut passed into the cavity. The depressed area of bone, being only slightly below the skull surface, and being adherent to the dura mater, was not interfered with.

The abscess cavity was irrigated daily; small flakes of bone came away from the inflamed outer table, and recovery ensued. [*Ref. No.* 105.]

Comments.—In none of the above cases was a foreign body demonstrated either by radiography or operation, and, if originally present, had probably been removed during the primary operation at the front.

The surgeon's greatest difficulty is the effective treatment of those cases in which there is in the brain a septic track surrounded by inflamed brain tissue; and the question arises: What is the usual fate of these patients if no operation be performed?

Methods for draining the inflamed area are numerous, and range from tubes of either metal or rubber, to the insertion in the brain of such substances as sterile glycerin or tablets of salt; but the recorded results of such treatment are meagre. Decompression (subtemporal) at a distance from the infected area has also been advocated.

Opinions probably differ as to the wisdom of laying open the septic track in the brain (as was done in Case 3); even if advisable, the limitations of such an operation, both anatomical and physiological, are obvious.

A CASE OF GUNSHOT PERFORATION OF THE STOMACH AND DIAPHRAGM OPERATION RECOVERY.

By Capt. V. B. GREEN-ARMYTAGE, I.M.S.

A sergeant, age 23, was admitted on Oct. 5, restless and dyspnœic, suffering from multiple bomb-wounds of the body received some six and a half hours previously. One fragment had passed through his left ankle-joint, and others had pierced the thighs in various places. But the most urgent was an abdominal wound, small and jagged, just above and to the left of the umbilicus. The abdomen was rigid in its upper segment, and the liver dullness was absent. There was no exit wound.

The patient was at once removed to the theatre, and under open ether and chloroform I first excised the entry wound, and then opened the abdomen through the left rectus for a distance of six inches.

As soon as the peritoneum was opened a large quantity of air and gas escaped, and then, on retracting the wound edges to expose the stomach area, a curious phenomenon occurred, namely, the patient commenced to respire with a loud whistling sound through the laparotomy wound; and, moreover, with the fingers it was possible to feel a ragged wound in the diaphragm in close proximity to the upper pole of the spleen.

On fully exposing the stomach, gas and slight food débris were seen to be coming from a hole the size of a threepenny piece near the lesser curvature. This hole was immediately doubly sewn over with silk Lembert sutures. As the bomb fragment had passed right through the stomach, travelling very obliquely, it was necessary to attempt to expose and suture the posterior stomach wound. To do this, having turned up the transverse colon, the mesocolon was incised as in a posterior gastro-enterostomy, and a good view obtained. But, though one could feel the wound with the finger tips, one could not expose it or bring it down sufficiently to suture it, for it was high up on the posterior surface. I was then in a dilemma, whether to incise the anterior wall in order to close the posterior wound; or, as his condition was not very satisfactory, to close the abdomen and trust that by sitting the patient upright, and by mouth starvation, the peritoneum would be kept clean. I chose the latter course, and as I wished to establish a positive abdominal pressure, so as to tend to close automatically the diaphragmatic hole, through which he continued to respire, I sewed the wound up in three layers. For

three days he was very ill, but after that he went on splendidly, and was sent down to the base on the tenth day.

The abdominal wound healed by first intention, and I have heard from him to-day, Nov. 12, that, except for his ankle wound, he is fit.

I have thought the case worthy of record for the various instructive points in its issue and the treatment adopted. In that I did not suture the posterior wound, or drain the peritoneal cavity, I think I was justified.

INTUSSUSCEPTION OF THE APPENDIX.

By GEORGE JOHNSON, Gainsborough.

Charles Smith, age 63, consulted me towards the end of May for pain in the back. He is a blacksmith's striker by occupation, and the pain was such that it was very difficult for him to stoop at his work and to straighten himself when stooping. He localized the pain in the region of the back, just above the sacrum, on both sides of the middle line.

He said the pain was there even when he did not stoop, and was variable in degree. He felt ill apart from the pain in the back, but had no pain elsewhere and no definite symptoms, simply a general feeling of illness. The bowels were rather relaxed.

On examination, the man looked ill, and had a furred, brownish tongue. The pulse was normal. There were no definite physical signs, excepting that some dullness and deficient air entry were found at the base of the right lung. This was explained by an attack of pneumonia two years before.

The patient said that he had had several similar attacks of pain in the back during the past three years; on questioning him later, in the light of subsequent events, he said that the pain had usually been worse on the right side, and on some occasions had been accompanied by diarrhœa.

At the time, however, this history was not obtained, and the case was diagnosed as one of lumbago, and treated with the usual medicines and applications, and with much the usual lack of success. However, in six weeks' time the man seemed better, and nothing unusual had occurred.

I had not seen the patient for several days. Happening to call at the next house on July 5, I was asked, quite casually, to see him, because he did not seem so well. He was sitting in a chair, but had only just got up, at about 3 p.m.

He now complained that the pain in the back had increased again, and that in addition he had abdominal pain, which he described as "diarrhœa pains." There was nausea, but no vomiting, and the bowels were loose—he had had several motions during the morning. He said that the abdominal pains had commenced on July 1, and were becoming more and more severe.

I examined him in bed, and found that his pulse was 100 and temperature 98·6°. The abdomen was not distended, and it moved freely on respiration. There was, however, muscular rigidity over the right iliac fossa, and acute tenderness on pressure over McBurney's point. There was also some tenderness

on deep pressure in the right flank, and I thought that the man had a retrocæcal inflamed appendix. I sent him to hospital, and examined him again two and a half hours later. His pulse was now 120, but otherwise the condition was unchanged.

I performed the usual muscle-splitting operation, and opened the peritoneum. A large wad of inflamed omentum presented, and this was found to be adherent to the tip of the appendix, which was easily brought up into the wound. The omentum was ligatured, divided, and pushed up.

The appendix now appeared to be about an inch and a half long, thick, swollen, and congested. It was almost embedded in a mass of inflamed fat, which appeared to be deposited in the appendix mesentery in such a way as nearly to bury the appendix itself. The cæcum could not be pulled up, and it was found necessary to enlarge the wound. When this was done, it was seen that the cæcum also was embedded in fat, and that between the cæcum and what had appeared to be the base of the appendix was a thick, firm collar about three-quarters of an inch long, which, like the cæcum, was largely hidden in fat. This fatty deposit I thought to be in the nature of a Jackson's veil, and proceeded to clear the parts as far as possible in the circumstances, the difficulty being that the whole mass was inflamed and friable, and bled on the least touch, and that the usual landmarks were quite obscured.

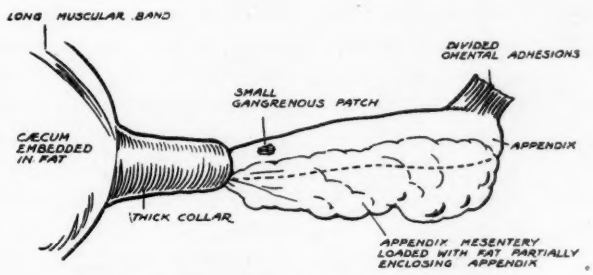

FIG. 207.—Intussusception of the appendix.

The condition was then seen to be very unusual: the appendix passed into the collar, and the appendix mesentery, thick and swollen towards the tip of the appendix, became much reduced in size and also seemed to pass into the collar; so that the condition now appeared to be that of an intussusception of the appendix towards the cæcum. Moreover, on the appendix wall, just distal to the collar, there was a small gangrenous patch which looked like an attempt at perforation. The condition of affairs was that indicated in the diagram (*Fig.* 207).

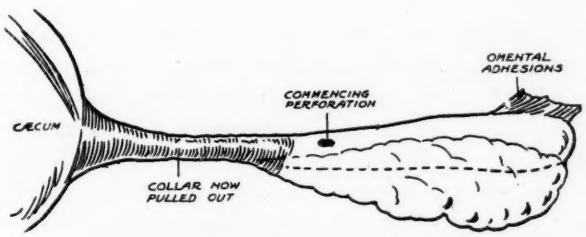

FIG. 208.—The intussusception reduced.

The only thing that appeared feasible was gently to dissect back the collar, commencing from the appendix end. The appendix mesentery was ligatured and divided, and the appendix freed down to the collar. By gentle dissection and very careful traction on the appendix it was found possible to reduce the intussusception, the condition then appearing as in *Fig.* 208.

It was very difficult to be certain where the cæcum ended and the appendix began, for the portion which had been collar was very dark and congested and looked fleshy, so that I feared for a time that the peritoneal coat of the cæcum had been stripped back and a tube of muscle and mucous membrane pulled out. This, however, proved not to be the case; and as the patient's condition was, by this time, not very good, I simply ligatured off what appeared to be the whole of the appendix, and closed the wound as quickly as possible.

The patient made an excellent recovery, but had a slight cerebral hæmorrhage three weeks after his operation. He has now recovered from this also, with the exception of a partial ocular palsy which still persists.

On examination of the appendix, it was found that the wall was very swollen and congested and contained many petechiæ. In one small area it was becoming gangrenous, and proximal to this the wall was dusky and congested and full of small hæmorrhages. The lumen was wide distally and narrow proximally, but nowhere really obstructed. There was no stercolith, and no evidence of a growth.

The interest of the case lies largely in this, that one is inclined to wonder whether the previous attacks of pain in the back, with diarrhœa, were really attempts at a previous intussusception, and whether the process was arrested either by the omental adhesions or by the peculiar wedge shape of the organ produced by the great infiltration of the mesentery by fat.

I am much indebted to Mr. Wilfred Trotter for his kindness in correcting the notes of this case.

A CASE OF TAMPONNADE OF A PERFORATED GASTRIC ULCER.

By EDRED M. CORNER, London.

Many surgeons fear to tamponnade a perforation because of the theoretical possibility of a lasting leak. A record of this case is therefore made to show that in practice there may be no leak; and a patient who in all probability would otherwise die, may recover, if a shorter operation be done which may enable him to husband his remaining strength.

The patient, a male, age 36, had had pains in the upper part of the abdomen for many years, especially after food. Hæmatemesis occurred three years ago. On Sept. 13, 1915, he had a sudden attack of severe pain in the right hypochondrium. He was not sick. The pain gradually grew worse, and he came to hospital, where he was admitted the following morning. He was extremely rigid all over the abdomen, but tenderness was most marked in the upper part. The temperature was 99°, pulse 90. There was local loss of liver dullness. He had not been sick, and acute abdominal condition was diagnosed. Battle's incision for appendicectomy was done, and the appendix found normal except for redness on the outside. Another incision was then made, higher on the abdominal wall. On examining the stomach, a perforated gastric ulcer was found on the anterior wall of the

pyloric end. No attempt to suture the perforation was made, but a gauze tampon was inserted to and around the place of perforation, and left in position. The incisions were then closed round the gauze in the usual way.

A rubber tube was left for drainage in the lower incision, as a certain amount of free fluid was present in the peritoneal cavity.

The patient was placed in Fowler's position after the operation, and rectal saline was injected every four hours. Nothing was given by the mouth for the first twenty-four hours; then he was allowed water, and milk and water, in small doses. The gauze was removed under an anæsthetic forty-eight hours after operation, and no evidence of leakage was shown. On the third day he was allowed to drink small quantities of beef tea, and a week later he started solid food. The lower wound became septic, but was very soon in a healthy granulating condition. The patient made an uninterrupted recovery, and left the hospital four weeks after the operation.

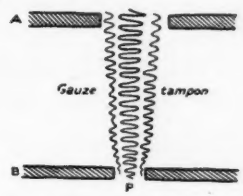

FIG. 209.—Diagram to show the method of inserting the tampon. A, Skin. B, Stomach wall. P, Perforation.

Fluid passing along a pipe having no resistance against it has little tendency to escape from a lateral opening. Hence, possibly, the absence of leakage from this unclosed perforation.

A CASE OF APPENDICITIS AND DIAPHRAGMATIC PLEURISY.

BY EDRED M. CORNER, LONDON.

This case is an example of the coincident presence of both appendicitis and diaphragmatic pleurisy; each making the other appear more acute than it really was.

E. T., a female, age 20, had had no previous abdominal trouble except obscure attacks of pain. On Sept. 20 and 21 she had diarrhœa. Two days later she was seized with general abdominal pain and headache, and later with tenderness all over the abdomen. On Tuesday, the 24th, the pain became most marked in the *left* side. The temperature on the 23rd was 102°. She was not sick. The bowels were open and the periods normal. She had a rigor on the 23rd.

When examined at home, the patient was tender and rigid all over the abdomen, which was especially tender over the right iliac fossa. Respiration was very shallow. An early and acute abdominal condition, probably appendicitis, was diagnosed. She was sent to hospital. The jolting of the ambulance probably caused deeper respiration, for when she arrived at the hospital the pain was specially marked at the height of inspiration. Diaphragmatic pleurisy was certainly present, as there was a pleuritic rub audible on the left side. The tenderness and rigidity thus caused hid the signs due to the appendicitis. Next day she was examined with the *x*-ray screen. Both sides of the diaphragm moved poorly, especially the *right* side. No evidence of subdiaphragmatic abscess was seen.

The patient settled down, but still complained of pains in the right iliac fossa; temperature normal, pulse 65 to 80.

A fortnight after admission it was decided to do a laparotomy, as the patient still complained of pain and tenderness in the right iliac fossa. Battle's incision for appendicectomy was made. The appendix was constricted in the middle, and presented evidences of recent inflammation. It was removed, and the stump invaginated and retained with a purse-string suture.

The patient made an uninterrupted recovery. The pain and tenderness in the right iliac fossa disappeared, and she left hospital perfectly fit.

A CASE OF EXOPHTHALMIC GOITRE AND ANOCI-ASSOCIATION.

By EDRED M. CORNER, London.

This case is interesting in connection with Dr. Crile's assertions of the benefits, psychic and physiological, of anoci-association.

The patient, a woman, age 27, had noticed exophthalmos for the last five years, growing worse lately. She first required medical assistance for a dermatitis of the left leg, which had been treated for two years at a skin hospital without any improvement. She consulted a skin specialist, who discovered the symptoms of Graves's disease. She had had occasional attacks of diarrhœa, and felt very nervous and excitable. She was ordered complete rest in bed, and stayed there for eight weeks. As the symptoms did not improve, an operation was advised. On admission to hospital, the patient was found to be well nourished, but markedly nervous and excitable. Her pulse-rate was 120, but increased with the slightest provocation. Tremor of hands and exophthalmos were well marked. The tonsils and spleen were moderately enlarged. The thyroid was just palpable on both sides.

Pre-operative Procedures.—The patient was told that she would be given gas every day until a favourable time for operation. For three days previously to operation she was taken to the theatre and placed on the operating table, and N_2O and oxygen were administered for about ten minutes. The neck was painted with 3 per cent picric acid, and bandaged. The pulse-rate always rose by 10 beats or more. On the day of the operation, five minims of atropine and ten minims of morphia were given one hour before she was taken to the theatre.

Operation.—As usual, anæsthesia was induced by N_2O gas and oxygen. The skin was painted with picric acid, and locally anæsthetized with 2 per cent novocain. The platysma was exposed, and quinine-urea-hydrochloride injected into the tissues until the thyroid was reached; it was then injected around the thyroid. The right lobe was removed, and the bleeding points were ligatured. The wound was then closed in layers, subcutaneous catgut being used to close the skin incision. No drainage tube was left in.

The pulse-rate before anæsthesia was 112. After the operation the pulse-rate was taken hourly, and was as follows :—

4 p.m.	126	Four beats less than after the mimic operations done previously.
5 „	140	The patient discovered that she had been operated upon by the dressing 'sticking.'
6 „	120	
7 „	128	
8 „	120	
9 „	120	
10 „	120	
11 „	124	

The patient was kept under morphia for twenty-four hours after the operation. Atropine was also injected every six hours in four-minim doses. Three days after the operation the pulse was quite steady, and its rate was 100 beats to the minute. The patient felt quite comfortable.

The pulse-rate has come down to 80 to 85. The patient feels very fit. The exophthalmos is less marked. The spleen is no longer palpable.

Since this was written the patient has continued to improve, which she had failed to do prior to her operation, in spite of two months' rest in bed.

On Oct. 21, 1915, she was shown at the Medical and Physical Society of St. Thomas's Hospital.

RETROPERITONEAL HERNIA: AN ADDENDUM.*

By A. RENDLE SHORT, Bristol.

I am indebted to correspondents for the following additional cases of retroperitoneal hernia :—

Left Duodenojejunal Fossa.—

Boy, age 5. Symptoms of acute intestinal obstruction. Mass felt in abdomen. Operation. Cure.—(F. C. Pybus.[1])

Foramen of Winslow.—

Adult male. Symptoms of acute obstruction. Operation. Reduction was successfully carried out, but the patient died seven days later.—(C. A. Morton.[2])

Male, age 58. Symptoms of acute obstruction. Operation. Cure.—(T. Sinclair.[3])

In Messrs. Moynihan and Dobson's book only 12 cases of this latter condition are described ; Jeanbeau and Riche[4] bring the list up to 20 in 1906. The total is therefore 24 at present. Of these, 5 have been cured out of 13 operated on.

REFERENCES.

[1] Pybus, *Brit. Med. Jour.*, 1914, ii, 14.
[2] Morton, *Ibid.*, 1909, i, 641.
[3] Sinclair, *Ibid.*, 646.
[4] Jeanbeau and Riche, *Rev. de. Chir.*, 1906, 435

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* See British Journal of Surgery, 1915, July, p. 48, "A Case of Retroperitoneal Hernia Cured by Operation, with a Report on the Literature of the Subject."

REVIEWS AND NOTICES OF BOOKS.

Collected Papers of the Mayo Clinic, Rochester, Minnesota: Vol. VI., 1914. Edited by Mrs. M. H. MELLISH. Large 8vo. Pp. 814, with 349 illustrations. London and Philadelphia: W. B. Saunders Co. 24s. net.

THIS volume is on the same lines as its predecessors, and while it possesses equal charms, it has similarly the faults inherent in all collections of scattered papers, some of which are of very ephemeral worth, like most contemporary surgical literature. There is naturally much repetition of statement when, side by side, are presented papers read by an author before different societies or published in different journals on a subject in which he is at the time interested; but an effort has been made in the present volume to obviate this by abstracting some of the articles. The visitor to the Mayo Clinic does not find his mind staggered with originality of view-point or unorthodoxy of treatment, but rather is filled with admiration mixed with envy at the general level of performance and organization: so in this volume there are no new truths disclosed likely to rend into opposing camps medical societies before which they are discussed, but further sound clinical observations are made on subjects for which the Clinic is renowned, and the scientific departments never fail to do good work with the operation material placed at their disposal.

Again, the work of the Clinic is accurately reflected in the relatively large amount of the space given up to some particular type of surgical lesion such as ulcers and growths of the stomach, or to diseases of the thyroid, though the latter organ looms less largely in the pages of the volume under consideration than in several of its predecessors.

What one particularly regrets is that the position of the Clinic in an isolated country town confines the activities of the staff to certain types of case, and especially keeps from their observation most acute injuries and diseases; so that we do not read here of injuries of the skull, or of diseases of the brain and spinal cord; very little of the treatment of fractures, or of the numerous conditions coming under the heading of the 'acute abdomen'; for the clinical view-point of their surgery is so clear, and the treatment usually so logical and thorough, that it is certain that the surgeons would spread an illuminating influence over many less well-known surgical lesions, and give their readers and pupils much useful instruction, were their clinical field a wider one.

It seems fitting to notice first one of two short papers by the editor of this volume, and librarian to the Mayo Clinic, Mrs. Mellish, for one cannot help feeling that had it been read and discussed at one of those most pleasant and instructive evening meetings of the members of the Clinic held weekly in the library, some of the papers which make up a bulky volume would have been sternly revised, if they had been included at all.

There is so much good material in American surgical writings that it is pitiable how lamentably careless on the whole authors are "in the choice of words, in the arrangement of phrases, and, in general, in the consideration of the impression which will be conveyed to the reader." It is to be hoped that each contributor to the book under review has by this time read and digested Mrs. Mellish's sermon, and that such phrases as the following, taken haphazard from different pages, will not recur in future numbers: "In early fetal life the first half of the large intestine contains villi *the same as* the small intestine;" or again, "The abscess developed around the ligature later, *which* was passed by urethra."

Some of the most valuable and lasting work of the Clinic in our opinion emanates from the pathological department, and here the trend of thought is indicated by

Dr. MacCarty's paper on the *Etiology of Cancer*; in this he amplifies and generalizes on the view, put forth in the 1913 volume in connection with mammary growths which regards epithelial hyperplasia as being primary, secondary, or tertiary. Here he is discussing the relation of the secondary hyperplastic (precancerous) cell to the tertiary or malignant cell, and illustrates a well-reasoned and lucid article with a large number of beautifully reproduced microphotographs and apt diagrams which illumine the letterpress to an unusual degree.

There is nothing new in Dr. Balfour's description of the technique of the double resection of goitres to those who have been privileged to see this operation done by several members of the Clinic as often as even a brief visit to Rochester allows; but the writer is personally grateful for it, having recently searched the five previous volumes for a clear and complete account of this operation as done in the Clinic by a modification of the Mikulicz resection.

We find much to disagree with and criticize in Dr. Henderson's long *Study in the Treatment of Fractures*; the author shows from frequent quotations that he has at least superficially studied the British Medical Association's report of 1912 on this subject, yet his statement that "a perfect anatomical reposition of the fragments is not essential for excellent function," is certainly not the lesson which that Report was intended to convey, and in our opinion denotes a woeful state of mind for one attempting to attack these problems. Autotransplantation of bone undoubtedly has its uses, but that "it must inevitably supersede the use of the plate" is quite open to argument. It would appear to the writer that one of the essentials in the operative treatment for delayed or non-union is the absolute fixation of the fragments; this is immediately, accurately, and finally secured by screws fixing a plate in a way and with a certainty which cannot be assured by the use of an Albee's inlay graft, held in position by wire loops or catgut sutures between the periosteum of the graft and that of the shaft. Lane's writings are freely quoted in these 'studies,' and several examples of failure after operation by his method in the hands of his imitators are given, yet the fundamental principles of his practice seem to be ill-understood. It has been truly said that American surgeons, while not themselves creative, closely observe and later put in practice much that is best in European surgery, and in doing so often improve on the work of those whom they in the first instance copied. It would appear to the writer that in spite of the theoretical acquaintance of American surgeons with Lane's work on fractures, and of the fact that a very large number of them have actually visited his Clinic, this subject affords a unique exception to the above truism. The originator of the method would certainly not expect a short light plate as shown in *Fig.* 227, p. 537, to hold a fractured femur, nor is the following a true picture of the experience of most English clinics: "In our Clinic many cases of fractures of the shaft of the femur have been operated on by using a metal plate. These patients volunteer the information that up to the time their surgeon permitted them to commence weight-bearing the leg was straight. . . . Bowing occurs on beginning to use the leg."

Among several papers from the pen of Dr. W. J. Mayo on the surgery of the stomach and duodenum, that on *The Radical Operation for Cancer of the Stomach* is particularly helpful; in this he favours the 'one-stage' operation, and reports that he has investigated the method of Polya for the restoration of the gastro-jejunal channel. The drawings which illustrate this paper are in their way perfect: the combination of anatomical accuracy with surgical technicalities and artistic clearness form an excellent model for all draughtsmen engaged in this kind of work.

In our practice it has seemed that the most difficult and most risky part of gastrectomy is the safe closure of the divided duodenum, and this Dr. W. Mayo attains by a continuous running suture over a clamp, as he has described elsewhere.

The same author's paper on *Resection of the First Part of the Large Intestine*—presumably for the same type of case for which Lane does a more extensive resection—appears to us inconclusive, and if the premises on which it is founded are correct, one must logically conclude that the splenic flexure and sigmoid loop are also at fault in this type of case, and that Lane's operation offers a wider chance of benefit. The restoration of the peritoneum over the posterior abdominal wall is ingenious

but we can scarcely think it necessary, as spontaneous re-formation of peritoneum over this area very rapidly follows a colectomy, and further, we have never found any post-operative adhesions over this denuded area.

Several papers deal with gastric and duodenal ulcers in their relation to growth, from the radiologic standpoint and in discussion of their treatment. The vexed question of the treatment of ulcers of the body of the stomach receives no convincing answer; it is admitted that gastrojejunostomy is not entirely satisfactory, and for these (because of the menace of cancer) and for duodenal ulcers when accessible, Dr. W. Mayo advocates excision. Balfour inserts a note on the destruction of gastric ulcers by the cautery which may supply a useful alternative, but its application is obviously limited, and unfortunately not available in exactly those cases in which resection is a formidable and dangerous proceeding.

Dr. C. Mayo, with Dr. Beckman, advocates visceral pleurectomy for the treatment of chronic empyema; this is largely a continuation of two papers by the latter author on the same subject in the 1913 volume. No doubt the Fowler operation here advocated is a helpful addition to Schede's resection of ribs and parietes, but we doubt whether it can be relied on to replace the latter.

On p. 23 half a page is occupied by a recital of the characteristic signs of hour-glass stomach. The whole of this is copied verbally from an English author, yet there is no semblance of acknowledgement or reference. This is not the only instance of plagiarism in this volume; indeed, many of the authors of the several papers exhibit an almost Teutonic tendency to ignore the work of others, while borrowing freely in method and idea. As a second case in point may be mentioned Dr. Balfour's careful and well-illustrated description of a method of tonsillectomy, which readers interested in this class of surgery will recognize as closely following, if not exactly copying, that introduced by Waugh. Now we happen to know that this method was demonstrated in detail by Waugh to Dr. Balfour during his visit to London in the summer of 1914; yet in a paper "presented for publication on December 2, 1914," there is no more definite acknowledgement of the source of the method than is contained in a sentence which is found in the paragraph preceding the description of the operation, as follows: "A modification of the Waugh method was introduced into the Mayo Clinic some four or five years ago by Beckman." We should be interested to learn the meaning of the word modification; in our opinion it would be more fair to state in the text where the method follows Waugh and where it is original.

We have before referred to the excellence of some of the figures which illustrate the letterpress; we need only say that nearly all of them are worthy of modern American publications, and in striking contrast to so many inferior pictures which still appear in English text-books of repute. The drawings of Ralph Sweet and of Miss E. Fry aptly illustrate the text and assist the reader. If we exclude that on p. 410 (where the cut ends of the facial and spinal accessory nerves appear in positions to which we are unaccustomed) they are anatomically correct, and no effort is made to unduly elaborate surgical detail by which their clearness would be prejudiced.

That other questions than those of pure surgery exercise the minds of the chiefs of the Mayo Clinic is shown by one of the concluding papers in which Dr. C. Mayo discusses *The Hospital as an Educational Institution*. Here he briefly touches on many aspects of this question, such as hospital efficiency, the careful, accurate recording of cases, and the protection of life; but we miss any detailed reference to the duty of a hospital with regard to the education of the medical thought of the nation in its widest sense, or any indication that one of the clearest brains of the Mayo Clinic has evolved any principle on which the Institution should make itself felt in this relation; in fact, hitherto there is no suspicion that within itself there has been as yet the beginning of any self-accusatory regret that all that is possible has not been done in this particular line. We all know that the younger members of the Clinic obtain a thorough education in the science and practice of medicine and surgery, and that visitors from all portions of the globe are welcomed to share these advantages to a degree which many older institutions might follow with benefit; but this scarcely takes a wide enough view of the Clinic's duty and responsibilities.

It is not our purpose to analyse the initial aims of its founders, or to follow several commentators in denouncing its commercial success as a paralyzing reason for its unwillingness to attack certain less praiseworthy features to which medical practice in the States is prone to a degree unknown on this side. It may be urged that quiet example is of more efficacy than loud-spoken precept in the quelling of unbridled advertisement, or in the maintenance of the correct attitude of the consultant to the general practitioner; these are but small points in a general question which the Mayo Clinic must face, and on which its position demands that it should take a lead. We hold the Mayos in such high esteem, and regard their reputation as so valuable a factor in instructing professional thought in their country along the highest educational and scientific lines, that we beg them to give these questions their due measure of consideration.

The Operations of Surgery (Jacobson). 6th edition. By R. P. ROWLANDS, M.S., Lond., F.R.C.S. Eng., Surgeon to Guy's Hospital, Lecturer on Anatomy to the Medical School, and PHILIP TURNER, B.Sc., M.S. London, F.R.C.S. Eng., Surgeon to Guy's Hospital, Teacher of Operative Surgery to the Medical School. In 2 vols. Pp. 1964, with 797 illustrations (40 in colour). Large 8vo. London: J. & A. Churchill. £2 10s. net.

THE appearance of a new edition of Jacobson's *Operations of Surgery* is an event of great interest and of no little importance to English-speaking surgeons. Those who were engaged in operative work a generation ago will still remember with gratitude the joy which came from the possession of the famous first edition. There was no book quite like it, none which seemed to have forestalled the difficulties even of the practised surgeon with equal insight, and there was certainly none which more fully repaid frequent reference to its pages. The chapters were scanned with eager delight, and with a never-shaken confidence that help and guidance would be given where most they were needed. The first edition was beyond doubt one of the English surgical classics, ranking with Greig Smith's *Abdominal Surgery*, and Sir Henry Morris's work on the *Surgical Diseases of the Kidney*. Not all the succeeding editions have quite upheld the standard set in the first, and one regards a new edition jealously, to see what treatment has been given to an old and well-tried friend. It may be at once acknowledged that this edition, the sixth, is fully equal to any of its predecessors, the first only and always excepted.

Mr. Rowlands is responsible for the editing of the greater part of the work; Mr. G. Bellingham-Smith has largely re-written the chapters dealing with operations upon the uterus and ovary; and Mr. Turner has revised the chapters concerned with the surgery of the head and neck, chest, and upper extremities.

A valuable chapter which has been added at the opening deals with the examination and preparation of the patient. We regret, however, to see what appears to us an undue emphasis laid upon the risks of operation in diabetes. The surgery of the gall-bladder and pancreas shows that the extreme opinions formerly held, and here extolled, are not tenable in a large majority of cases. It is only when septic conditions are added to diabetes that the risks of operation are grave.

The instructions given as to a stern operative technique are marred by an undue laudation of the value of iodine as a skin disinfectant. It is said that "within the last few years it has been recognized that an alcoholic solution of iodine has remarkable powers of destroying cutaneous organisms." The experiments of Robb seem to show, however, that when the excess of iodine is removed by washing with a 10 per cent solution of iodide of potassium, bacteria can almost always be recovered from the skin. Robb and others (Loiacono, Tinker, and Prince) have demonstrated that sterilization of the skin by iodine is not efficient. The simplicity of the iodine technique is of course delightful, but it seems often to have the effect of making all other steps, in a ritual which should be scrupulous, of the most perfunctory character. There are signs on all hands that the efficacy of the method is being questioned.

We are sorry to find the paragraphs dealing with anæsthetics so short. The anxiety concerning the efficient administration of ether or chloroform, etc., cannot always or wholly be placed upon the shoulders of the anæsthetist. Such dangers—

very real ones—as post-operative chest complications, acidosis, or chloroform poisoning, are not witnessed by the anæsthetist; they are the surgeon's care; a few words of warning and instruction would be invaluable.

The operations for the ligature of vessels, excisions of joints, and amputations, are described with great detail, and excellent judgement. Of the text, no praise could be too high; an illustration here and there is perhaps a little trivial. A good account is given of operations on the fifth nerve, though a full reference to the work of Harvey Cushing, and a well-illustrated description of his operation upon the Gasserian ganglion, would have added greatly to the value of the chapter; and his results should certainly be quoted.

The operations upon the head and neck are admirably described. The account of that interesting condition, œsophageal pouching, is very good. An *x*-ray photograph should be included in the next edition, for this makes the diagnosis, never very difficult, a matter not of opinion only, but of clear demonstration.

A very full and well illustrated account of the surgical treatment of carcinoma of the breast is given. We are glad to find due recognition of the great work of Sampson Handley. The work of Rodman, and points in the technique of the operation as done by him, are worthy of mention. In connection with the *x*-ray treatment of patients after operation, as a prophylactic measure against recurrence, it is said "at any rate it could do no harm"; an opinion which is questionable in all cases, and is certainly wrong when a subsequent local removal has to be performed. Thomas's method of removal of simple mammary tumours is, we think, worthy of large print.

The second volume opens with a good account of the several forms of hernia and the operations for the radical cure of this condition. The century-old error that in inguinal hernia the site of the stricture causing strangulation lies in the neck of the sac, is repeated. And the unfortunate counsel is given that after a radical cure it is desirable for a patient to wear "a truss of light pressure or a belt."

The account of the surgery of the stomach is throughout accurate, intimate, and well illustrated; acknowledgement of the sources of the figures is not always made. As a matter of surgical history it is worth noting that the operation described as "Abbe's modification of Kader's method of gastrostomy" was first published by Stamm, of Cleveland, from whom credit, by persistent ill-fortune, seems always withheld. In the account of excision of gastric ulcer, there is no evidence or opinion brought forward as to the value of this operation, practised alone. We believe that the surgeons most versed in this matter are inclining more and more to the dual operation of excision and short-circuiting, because of the unsatisfactory after-results when nothing but removal of the ulcer is performed. Recurrence of the ulceration, with hæmorrhage or perforation, seems to occur in a disquieting number of cases. The account of subphrenic abscess is a little sketchy, and insufficient regard is paid to the excellent papers of the late Harold Barnard. The references in several places are a little behind the times—e.g., W. J. Mayo is quoted as reporting 114 gastro-jejunostomies for carcinoma in 1905, and Moynihan 35 in 1901. Where experience has been so rapidly gained, these references smack of ancient history.

The section dealing with intestinal surgery has been almost completely re-written, and all modern work of value has been carefully scrutinized. The account of resection of the colon for carcinoma is very good, though perhaps a little more space might have been given to Paul's method of removal in two stages. It was Lowson, not Lawson, who first removed the ileocolic angle in the manner brought later to perfection by Friedrich and others.

We confess to a little excited anticipation of what the author would be able to say of the treatment of intestinal stasis by surgical methods, and especially of the operation of complete colectomy, which is one of the debts we owe to the surgical genius of Sir Arbuthnot Lane. It is a little disappointing to find many quotations from other authors, and very little indication of the view taken of the subject by an observer at close range. The operation of complete colectomy is said in Lane's hands to have "practically no risk." It would have been an invaluable piece of evidence if a record of this operation for stasis, its mortality and results, soon and late after operation, could have been given.

The description of intestinal obstruction is for its length the best in the language, and it is evident that Mr. Rowlands has made the very utmost of his large experience in a branch of abdominal surgery that is perhaps the most difficult of all.

The operations on the gall-bladder and bile-ducts are, we think, allotted too small a space, but the counsel given is sound and the directions explicit. An excellent account is given of excision of the rectum, especially of the abdomino-perineal operation, based upon the work of Mr. Miles.

Throughout the whole work it is evident that there is still a need of revision, and of later and more accurate references to literature. Several names are misspelt, Clairemont, R. Morrison, Halstead, Lawson, for example; Pearce Gould has still to be content with the prefix 'Mr.,' and Henry Morris and R. J. Godlee have not yet received their baronetcies.

But any criticisms we make must not be held to indicate anything but the warmest admiration for this work, and for the diligence and scholarship which have gone to its production. The book is so good, and has been so long an invaluable friend and companion, that its readers, no less than its authors, are concerned in its reputation. We consider the work beyond rivalry, the best of its kind in our language.

Wounds of the Thorax in War. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.) By J. Keogh Murphy. Small 8vo. Illustrated. 1915. London: Henry Frowde and Hodder & Stoughton. 2s. 6d. net.

Though this series is intended, as the handy pocket size of the books shows, chiefly to provide help and guidance amid unfamiliar problems to medical officers working close to the battle lines, the writers in it are for the most part men who for one reason or another have been compelled to draw their experience of military surgery from what is seen in the hospitals of England. In part, that is an advantage, for it should make possible a description of the final results of wounds and their treatment among those who have survived. The rest is all disadvantage. No man, however great his clinical powers, can divine precisely the problems of diagnosis and of treatment which will arise in dealing with soldiers wounded in the field or in process of transport down the lines of communication to England. Experience alone can supply the knowledge which will give the needed help.

Realizing this, the writers of some of these manuals have practically restricted themselves to a general and admirable account of the principles underlying the treatment of wounds and injuries in the parts of the body allotted to them by the editors, and they have left it to the men in the field to complete from these general theorems the practical deduction of what should actually be done. Mr. Keogh Murphy has had the advantage of some practical experience in dealing with wounds of the chest soon after the injury had been received. But one can only conclude with regret that his opportunities for observation had been few, and his leisure to study the subject had been small, for this primer gives a very incomplete account of the accepted principles of thoracic surgery, while the practical advice which it contains is for the most part a contradiction of what has been taught by observers of wide experience in France. A fluency in writing, which at times is almost reminiscent of journalistic ease, may serve to make his readers either more or less critical of the essential matter of the book.

The war is altering many things in thought and life, but it has not created military surgery *de novo*; and one would wish even in a small treatise to read an account of such general principles of thoracic surgery as have been enunciated by acknowledged masters of the subject. In this manual the only detailed reference is to the experiences of Sir George Makins in the South African War. Yet Makins' conclusions are open to much criticism, and even his experience was far from being fully representative. For example, he met with only two cases of primary infection of a hæmothorax, whereas W. F. Stevenson, in a series of 214 wounds of the chest, reported 62 cases of hæmothorax and 32 with empyema. Sauerbruch is dismissed on p. 78 with a half contemptuous reference to his method of operating in a special pneumatic chamber; and one blushes to think of the opinion in which foreign readers will hold our English ignorance if they see that the chamber is supposed to work with an *increased* pressure of air. The very essence of the device is to imitate the negative intrapleural tension

by lowering the external pressure. This error can only be the result of a misconception by the author of the physical factors involved. For the corresponding slip on p. 45, where the air in subcutaneous emphysema is said to be forced from the bronchus into the tissues "on inspiration," one prefers to assume a mistake in writing rather than in thought. As for Sauerbruch, *fas est ab hoste doceri*; he has long been one of the most eminent thoracic surgeons of Europe, and his article in *Bruns' Surgery*, 1913, contains an account of hæmothorax and of chest wounds which anticipates and covers almost all the points that have yet been noticed in this war. Indeed, it is in all respects so admirable, that one cannot but feel that an English digest of it, adapted to military exigencies, would have been infinitely more helpful to surgeons than anything else on the subject that has yet appeared.

The arrangement of the subject in the primer under review does not proceed in any very strict order. For the purpose of criticism, one may take an outline plan similar to that of Sauerbruch, and consider the teaching of Mr. Keogh Murphy's book in relation to the main details of such a scheme. Penetrating wounds of the chest may cause laceration of the lung, and either a hæmothorax or pneumothorax, or all combined. Septic infection may be added to any of these injuries, and then it dominates the whole picture. Laceration of the lung is not very common, but its right treatment is of the utmost importance. The condition is disregarded in this book.

Treatment of the various conditions must be considered separately at the three main halting-places for the wounded soldier—that is, near the front, in the base hospital, and ultimately in England. All agree that the primary treatment must be by rest, morphia, and *occluding* dressings to the wound. The egress of blood and the insuction of air, together with skin infections, must be checked; and tubes should never be carried into the pleural cavity. But there is a possible scope for skilled surgery in saving life at the front, particularly in cases of ingravescent pneumothorax. This has not yet been considered in any of our military publications, and Mr. Keogh Murphy is altogether silent upon it.

Treatment at the next stage will be governed by the nature of the lesion. The primer (p. 35) advises that if ribs have been extensively smashed, the wound should be freely opened and the fragments removed. This advice can only be criticized on *a priori* grounds, and not by the fruits, good or ill, of such a procedure; for it is the custom of surgeons to provide free drainage on the surface, but to avoid most carefully all interference with rib fragments, lest rents in the pleura be opened and infection introduced. The majority of cases so treated recover very satisfactorily, and a delayed spread of the infection inwards is rare.

A hæmothorax, we are told, is admitted by all to be formed by slow bleeding from torn vessels in the chest wall. Sauerbruch is one of many who think otherwise. At any rate it is surely wiser to act on the assumption (cf. *The War Office Memorandum on War Injuries*, 1915) that the blood is derived from the lung, for then it is easy to appreciate the value of rest in checking hæmorrhage; and then, too, one can understand how the rise of intrapleural pressure and the collapse of the lung will combine to put an end to further oozing. Hæmorrhages at a later date are rare. The change of physical signs and the rise of temperature referred to on p. 51 as examples of secondary hæmorrhage were probably caused by an effusion of inflammatory fluid, which is often excited by the presence of the hæmothorax, though to bacteriological tests the latter appears to be sterile. There is no discussion of this inflammatory reaction, nor of the nature of the coagulation process in the effused blood, a subject upon which some interesting remarks are made in a paper by Bradford and Elliott in the October issue of the BRITISH JOURNAL OF SURGERY; but the omission is not of much moment where treatment is the chief object in view. Very gloomy is the prognosis that Mr. Keogh Murphy gives for men with a hæmothorax; that they shall be chronic invalids, with pain and cough, until ultimately they fall victims to tuberculosis. And yet it is urged that the collection of blood should never be removed by aspiration. The arguments advanced by him against putting a needle into a hæmothorax do not require discussion, in view of the abundance of actual evidence which proves that, with reasonably strict care for asepsis, a needle will never infect a sterile hæmothorax, and that the aspiration of a large hæmothorax is a safe and beneficial mode of treatment. Incidentally to a question on p. 59, we

might point it out as a useful clinical rule, that where there is doubt whether blood removed by an exploring needle has been drawn from the chest wall, from the lung, or from an actual hæmothorax, the question is settled by the fact that fluid from a hæmothorax never clots in the syringe, and is nearly always of a darker colour than the freshly-drawn blood. Provided they have plenty of exercise later to open up the collapsed tract of lung, men with an old hæmothorax make a perfectly satisfactory recovery, so far as that injury is concerned. Cases have been reported where an effusion of sixty or more ounces has been aspirated, and the soldier has been fit again for light duty two months after his wound.

There is less, but still quite sufficient, occasion to disagree with Mr. Keogh Murphy's clinical description of an infected hæmothorax or empyema. The development of a pleural inflammation on both sides, as evidenced by an increase of tenderness on the side of the hæmothorax and of pleural friction on the other, is a valuable index of which we find no explicit mention. Constipation is a symptom of little value; but it should have been remarked that septic diarrhœa is frequently the token of a severe infection in a hæmothorax. Despite the statement on p. 65, one wonders whether clubbing of the fingers has really ever been observed in the first few weeks of a septic hæmothorax. It ought to be the aim of every surgeon in charge of chest wounds to discover as early as possible whether a collection of blood has been infected, and not to wait two or three weeks until it is self-evident that the chest is full of pus. A delay in resection later than the seventh or eighth day may in severe infections cost the wounded man his life. The surgeon must be thoroughly alive to the gravity of such sepsis. This does not mean that an exploring needle should be used in every case, but only that wherever clinical features suggest sepsis, the doubt should be decided at once, and, as Mr. Keogh Murphy rightly insists, the needle is the only arbiter.

In France, the fulminating cases, which, none the less, often recover rapidly as the result of early rib resection, are generally caused by contamination with anaerobic gas-producing bacilli. These organisms were present in 50 per cent of the cases examined by Dr. Henry, and yet we read that they were never met with in Mr. Keogh Murphy's experience. The bacteriological results of the men working with our army in France agree very closely with the general statements of Sauerbruch—namely, that the infecting organisms do not often come from the respiratory tract, but that nearly all are derived from the skin, being chiefly the streptococci and anaerobic bacilli of fæcal origin which are commonly found in all septic wounds of the surface. Against this, we have the somewhat obscure sentence on p. 69 of the primer, that "in my group of cases the skin was not the source of infection, but rather the track of the bullet and the alimentary canal or circulation, coupled with the weakened resistance of the body." However, one's faith in any of the author's bacteriological statements is shattered by the remark on p. 137 that *Bacillus coli* is a Gram-positive organism. The general opinion of competent workers is that the infected hæmothorax usually receives its infection with the primary wound. Occasionally organisms may creep in later from the septic wound of the thoracic wall, or from infarcted and infected areas of dying tissue in the lung. No reliable evidence has yet been met with to prove that a closed hæmothorax is ever infected through the blood-stream from a septic focus elsewhere in the body.

The discussion on the differential diagnosis of a septic hæmothorax is meagre. Pneumonia on the opposite side to the wound is one of the conditions to be taken into account. In France it has never been fatal, yet the primer states that it is invariably so. No mention is made of the much more serious complication by purulent bronchitis.

Mr. Keogh Murphy's teaching on the subject of pneumothorax is very difficult to follow. He found the cases to be frequent. Other observers say that they are relatively rare, but often supposed to be present, owing to the Skodaic phenomena which are exhibited by the emphysematous lung above an area of collapse. On the question of Skodaic signs the book says nothing. Cases of air, or of air and blood together, in the pleural cavity as the result of a lung wound are occasionally met with, and they are just as likely to remain sterile as to be infected. Yet Chapter vi seems to consider all cases of pneumothorax as being really examples of pyopneumothorax, caused by a slow leak of air, and of infection from an ulcerating wound of the lung.

Perhaps this view is an *a priori* deduction from what occurs in civil life among patients with tuberculous disease of the lungs. The evidence produced in its support carries little conviction, and it does not agree with the opinion of Bradford and Elliott. Curiously, the author has met with no case of pyopneumothorax produced by gas-producing organisms, though in France these are so familiar that medical officers with a little experience are accustomed to make a tentative diagnosis of that particular infection when they meet with a cracked-pot percussion note within a hæmothorax.

X-ray examination is of great help in cases of suspected pneumothorax, and at times it helps to explain completely the state of a chest in which the physical signs are of baffling complexity. But neither the *x*-ray officer nor the surgeon can interpret what is seen in wounds of the chest unless they have had some experience of the matter. It is a great pity that the primer gives no information on these points.

Ten pages out of the 150 are devoted to an account of vaccine therapy, which on the one hand the author employs for the later stages of chronic infection; on the other hand, in the earlier treatment of wounds he recommends a proprietary antiseptic solution known as 'iodex.'

Reading the book through, one is arrested at page after page by its faults, and yet at the end of it all one feels a sincere inclination to admire Mr. Keogh Murphy for his cheerful attempt and success in writing a manual on a subject of which his knowledge was relatively superficial. But it is a matter for regret that the book was ever published; for while the general title of the series will recommend it as being authoritative, the contents of this particular primer will only confuse and mislead those who seek instruction in its pages. The real blame does not perhaps rest with Mr. Keogh Murphy. The reputation of the Oxford Medical Publications is one which hitherto has never demeaned the dignity of a University Press whose name is founded on the old-time privilege of printing the English Bible, and on a succession of works of accuracy and scholarship. It is a serious thing to break away from this tradition, and in a carelessly written book to spread teaching which is partly mistaken, and wholly below the best that English surgery could give.

Memorandum on the Treatment of Injuries in War, based on the Experience of the Present Campaign. Small 8vo. Pp. 122, illustrated. 1915. London: Harrison & Sons.

THIS memorandum has been drawn up with a view to summarizing the experience gained in the military hospitals in France during the last ten months. The book is full of interest because it contains views on modern war surgery gathered from the personal experience of many trustworthy officers holding commissions in the Royal Army Medical Corps. It is published by authority, and is issued for the benefit of those who, urged by patriotism, have been suddenly translated from the peaceful sphere of civil practice to the turbulent scenes and makeshift methods which are only too often obligatory in war. This book consists of only 122 small pages of letterpress, with twelve illustrations, and an index; a great number of points are dwelt upon within this compass, of necessity with great brevity.

With a full knowledge of the limitations of field service, operation is wisely discountenanced until the patient is within reach of practised hands and more favourable surroundings. Much is written for the medical officer who has recently been commissioned, but some of the pages appeal to surgeons of greater experience. It is stated, for instance, that "Experience has been disappointing as to the efficiency of any antiseptic to inhibit bacterial growth within the fouled wounds produced either by shell fragments, by shrapnel, or by rifle bullets where the apertures of entry and exit depart from the simplest type. It has, moreover, shown that any medium is to be avoided which produces extensive coagula and tends to block the free exit of the wound discharges." Adequate drainage and the mechanical (as distinct from chemical) cleansing of wounds form the essential elements in the primary treatment of gunshot wounds. These statements are rather too absolute at present, and it should have been pointed out that many surgeons of equal experience hold other views. The flapless guillotine method of amputation, the re-introduction of which is attributed to Lieut. Fitzmaurice Kelly, is advocated in cases of anaerobic infection on the grounds that: (*a*) The amputation can be done at a lower level, since it may be carried through the infected tissues, which may recover later in consequence of

the free drainage provided; (*b*) The dangers to the patient of local extension of the infective process and of systemic infection are minimized; (*c*) The section of the soft parts may, without any disadvantage, be made to correspond in level with that of a fracture of the bone. The method is, in fact, a return to the military amputations of the sixteenth and seventeenth centuries. It is satisfactory in so far as some patients survive after its performance who would otherwise most assuredly have died; it is unsatisfactory because a second operation to trim up the stump is usually required. It is by no means suitable, therefore, as a routine operation.

The book is good as a whole; but here and there discrepancies are found, as in the statement on p. 6, where it is said that "in no case should impermeable tissue, such as jaconet, be placed on the surface;" whilst on p. 8 may be read, "The direct application of a thin sheet of rubber tissue to the whole wound surface has also been tried with success." There is a particularly full and interesting section dealing with gas-poisoning, and a shorter chapter on 'trench foot.'

In an official publication it would be congruous to employ the official nomenclature, and aspirin should in consequence be described as acetyl-salicylic acid.

Diarrhœal, Inflammatory, Obstructive, and Parasitic Diseases of the Gastro-intestinal Tract. By SAMUEL GOODWIN GANT, M.D., Professor of Diseases of the Rectum, New York Post-graduate Medical School. Large 8vo. Pp. 604, with 181 illustrations. 1915. London and Philadelphia: W. B. Saunders Co. 25s. net.

IN his preface Dr. Gant says that his object in writing this book is to give a complete and practical treatise on the treatment of acute and chronic diarrhœa; the title is, however, an unfortunate one, since it is neither practical nor scientific. So many really excellent medical text-books have appeared within the last few years from the pens of American authors, that it is disappointing to have to criticize severely the present work. Medical text-books may be said to be written with two objects, (1) to add to medical knowledge and thereby assist fellow practitioners in the practice of medicine, and (2) to advance the author's reputation. We are afraid this particular book will not secure either of these ends.

From a perusal of its pages it would be difficult to say what the subject of the volume really is, for it covers such various matters as the treatment of parasitic worms, carcinoma of the rectum, piles, psychic diseases, and injuries of the nervous system. The book starts with a chapter on the classification of diarrhœas: this, while extremely comprehensive, is based upon no scientific principle, and appears to be even less valuable than such classifications usually are. The best chapter in the book is that on tuberculosis of the bowel; but it is to be regretted that even here the author employs such useless forms of classification as those depending upon the situation of the lesion in the bowel; such terms as 'enteroperitoneal' and 'neoplastic' are merely confusing when speaking of tubercle.

Some excellent illustrations of hyperplastic tuberculosis are given, and a very clear description of this rare form of tubercle. We are sorry to see that the author still pins his faith to the use of the Murphy button in the treatment of tuberculous disease of the bowel by resection. In this country the Murphy button has now been relegated to the museum.

The last few chapters of the book consist of a description of nearly all the surgical procedures upon the rectum, colon, cæcum, appendix, etc., that have been devised within recent years. It is difficult to see what exact relationship these have to diarrhœa. On the whole we incline to think that the illustrations are the most valuable part of this work. These are excellently carried out, and the book is printed on very good paper.

The Alimentary Tract: A Radiographic Study. By ALFRED E. BARCLAY, M.A., M.D., B.C. (Cantab.), Medical Officer *X*-ray and Electrical Department, Manchester Royal Infirmary. Demy 8vo. Pp. 195, with 77 radiogram illustrations. London: Sherratt & Hughes. 15s. net.

THERE are few radiographers who have added more to our knowledge of the alimentary tract than Dr. Barclay, and the publication of a work by him on the subject is very welcome. In a previous volume only the œsophagus and stomach

were considered, but the author has wisely added some chapters on the intestines. In his preface the author tells us that he had originally intended to re-write and add to several chapters, and that that on the large intestine is far from complete; but he found himself unable to complete his book owing to the war. We think it would have been wiser for Dr. Barclay to have postponed the publication of his book until he was able to complete it more satisfactorily, as the want of revision is very evident in many parts.

The description of the methods of examining the alimentary canal by means of the *x* rays is admirable. The least satisfactory chapter is one in which the author propounds a new theory of the etiology of gastric and duodenal ulcers. This suffers from the fact that the author apparently examines cases with the *x* rays only, without the aid of other clinical methods, and it also shows some lack of knowledge of the large amount of experimental and pathological investigation that has been carried out on the subject.

The description of the physiology of different parts of the alimentary canal should prove useful to abdominal surgeons, and the author's important observations which have led to the recognition of the fact that tone and peristalsis in the stomach are entirely independent functions, and his confirmation of the new views as to the important functions of the ileocæcal sphincter and the normal activity of the colon, will be found of great interest and value, particularly to those who have not been able to keep abreast of the recent advance of knowledge of the subject.

The book is illustrated by numerous excellent skiagrams, and is completed by a valuable bibliography. Altogether it can be recommended to anybody who wishes to undertake *x*-ray examinations in disorders of the alimentary canal, and to all those who wish to be able to appreciate with a sufficiently critical mind the radiographer's reports of cases under their care.

Wounds of War: Their Treatment and Results. (Oxford War Primers.) By D'Arcy Power, M.B., Oxon., F.R.C.S., Eng. Small 8vo. Pp. 108, illustrated. 1915. London: Henry Frowde and Hodder & Stoughton. 2s. 6d. net.

This member of the Oxford War Primer Series will receive a cordial welcome. One of its many claims to consideration is that it is dogmatic, in the best sense. Directions for the treatment of various types of wounds at their different stages are clearly and concisely set forth, and one feels that by following these instructions one might obtain the same good results as the author himself. At the present time, when different workers are proceeding on lines which are not parallel but convergent, it is impossible to treat of this subject without introducing controversial matter. It may be said that Mr. D'Arcy Power is a powerful champion of the cause of antiseptic treatment of raw surfaces, and makes out an excellent case for the views he holds.

In the introduction, the author takes us back to the days before Lister, when most wounds suppurated. He deprecates the idea of what may be called the expectant treatment of merely sterilizing the surface and hoping for healing by first intention. He regards all war wounds as deeply infected from the first, and bases his principles of treatment on this assumption. He is impressed with the hopelessness of abolishing suppuration in the wounds sustained under the unfavourable conditions of war, and especially those conditions peculiar to the present war, such as a soil rich in bacteria, enforced long delay in first aid, and sudden heavy calls on our hospital equipment. At the same time he is hopeful of shortening the period of suppuration by suitable measures, and pays a tribute to the help given by other army services in keeping the men in condition to resist infection by good sanitation, food, and clothing.

The book opens with a description of the missiles causing the different kinds of wounds, and it is shown why the results of bullet wounds vary so much at different ranges, and how the explosive effect is produced. The author calls attention to the absence of relation between the external appearances and the actual internal damage.

Immediate treatment is next discussed. At this stage wounds are classified into: (1) Those seen immediately; (2) Those seen within the first twenty-four hours; (3) Those seen later. The first class may be cured without suppuration; the second should be treated with the idea of preventing suppuration; the third, as if suppuration were inevitable.

The difficulties of the situation are set forth in a description of the routine of transfer from the field of action to a base hospital. The best immediate treatment is often impossible, and a field dressing may have to suffice for many hours. The author's ideal plan of immediate disinfection of the wound is therefore often impracticable, and active treatment must perforce be delayed, perhaps even until the base hospital is reached. Here then, if not at an earlier stage, disinfection is to be carried out. The points of the technique are as follows: (1) A general anæsthetic for the patient; (2) Application of tourniquet when possible; (3) Full aseptic ritual for the surgeon and assistants; (4) Sterilizing of the skin surface; (5) Removal of blood and obviously soiled tissues; (6) Enlargement of the wound, if necessary, to expose its inmost recesses; (7) Swabbing of the whole of the raw surface with 1–20 carbolic; (8) Washing out excess of carbolic with normal saline; (9) Relaxation of tourniquet and securing of bleeding points; (10) Large drainage tubes to the bottom of the wound. The above treatment is considered suitable within twenty-four hours, or at most forty-eight hours, of the injury.

Frequently it happens that active treatment cannot be applied so soon, and the micro-organisms have had time to attain a firm hold of the tissues. After such delay the patient is somewhat exhausted and needs rest, so that immediate operation is not advised. Swabs are taken for culture, the wound is gently irrigated with peroxide of hydrogen, examined in a good light, pressure being made to ascertain whether there is tracking of pus, and such tracks are carefully explored with a sterile probe. The wound is dressed with a compress soaked in 1–2000 iodine or 3 to 5 per cent salt solution, renewed every four hours.

The interval of rest may be filled up by obtaining a bacteriological report, an investigation of nerve injuries, *x*-ray examination, etc.

The treatment described may prove to be all that is necessary. The wound is watched carefully for a few days. If there is any sign of spread of suppuration, as shown by exudation of pus on pressure round the wound, operation should now be undertaken.

The patient is anæsthetized, and with full aseptic precautions the wound is fully explored, all tracks being opened up and good counter-drainage established. "In the earlier part of his career the surgeon errs on the side of doing too little rather than too much." The author insists on free drainage by rubber tubes, and heartily condemns all plugging with gauze, except as a temporary measure to stop hæmorrhage. He recommends further the use of antiseptic baths where practicable, or otherwise irrigation with antiseptic solutions of carbolic, biniodide of mercury, iodine, sanitas, etc. In the intervals, fomentations or antiseptic compresses are to be used.

The broad principles of treatment are the following: (1) Prevention of multiplication of bacteria; (2) Constant removal of bacteria as they are formed; (3) Maintenance of the tissues in as healthy a state as possible; (4) Acclimatization of the body to the presence of toxins.

Mr. D'Arcy Power does not express his personal opinion of vaccine treatment, but gives it his blessing by inserting a chapter on vaccine therapy by Dr. Wallis of St. Bartholomew's Hospital, which gives an interesting outline of the rationale and technique of vaccine and serum therapy.

Chapter vii deals with shock, and injuries to blood-vessels, and gives in full detail the methods of tying all the main arteries. The author recommends instant proximal ligature in cases of secondary hæmorrhage, and uses silk ligature material.

In dealing with aneurysms, the following treatment is advised: For traumatic aneurysm—excision after ligature above and below. For aneurysmal varix—bandaging in mild cases, arterial and venous suture in the more severe, or, for surgeons of less experience, venous suture with ligature of the artery above and below. For varicose aneurysm—excision, and suture of vein.

Tetanus and gaseous gangrene are treated of in Chapter viii. Massive doses of antitoxin are advised for tetanus, combined with local excision of the wound. Gas gangrene is treated by high circular amputation, or, where this is impracticable, by free incisions.

The book concludes with a brief review of the general technique of amputations. Flaps are recommended except in special circumstances.

Cerebrospinal Fever. (Oxford War Primers. Under the General Editorship of LIEUT.-COL. D'ARCY POWER, R.A.M.C.) By THOMAS J. HORDER, M.D. Small 8vo. Pp. 179, with 17 illustrations. 1915. London: Henry Frowde and Hodder & Stoughton. 3s. 6d. net.

THE prevention, recognition, and treatment of cerebrospinal fever has become such an important matter in this country, that a book which deals with the subject in a simple and practical manner, as this does, cannot fail to be appreciated by those who may at any time be brought into contact with this complaint. The reader will find a clear account of the various clinical manifestations which the disease may assume, together with a description of the bacteriology. Detailed instructions are given for the management of cases; and the descriptions of the methods for taking cultures by swabs from the nasopharynx, and of making lumbar punctures, will be found particularly useful. The author does not think that drugs exercise any definite influence on the course of the disease, but considers that serum given by the intraspinal method affords the patient the best chance of recovery, and further, that the stage at which serum treatment is commenced is a most important factor in estimating the outlook in any individual case.

The printing and general arrangement of the book make it pleasant and interesting to read.

The Stretcher-Bearer. (Oxford War Primers. Under the General Editorship of LIEUT.-COL. D'ARCY POWER, R.A.M.C.) By GEORGES M. DUPUY, M.D. Small 8vo. With many illustrations. 1915. London: Henry Frowde and Hodder & Stoughton. 2s. net.

THIS little volume will be found an invaluable companion and supplement to the official R.A.M.C. training book dealing with stretcher-bearer drill and the handling and carrying of wounded men. The author gives no fewer than 138 full-page photographs illustrating the various positions and movements of the individual or the squad. The reader of the official manual is thus enabled to visualize his drill.

Illustrations of the method of unloading an ambulance wagon might with advantage be added.

International Clinics: A Quarterly Journal of Illustrated Clinical Lectures. Philadelphia: J. B. Lippincott Co. 4 vols. 35s. per year.

THREE volumes of this well-known publication, the first, second, and third of the twenty-fifth series, lie before us.

The vast majority of the contributions come from American physicians and surgeons; and, strictly speaking, the journal in question is American rather than international in its scope. This very fact is a testimony to the advance of transatlantic medical science. But we cannot forbear to note that while some of the articles attain a high scientific standard, there are others of only ephemeral or personal value, and yet others which are merely journalism.

The third volume contains an article on "War Experiences in Germany and France" by a medical student of Zurich. The author's visit to France, if not enforced, appears to have been dictated by the motto, *fas est et ab hoste doceri*, and the whole article may well have emanated from the German Medical Press Bureau. The author states, in reference to enteric fever, "In Germany, soon after the outbreak of the war, all the troops received prophylactic treatment at suitable intervals, while in France the greater part of the army had undergone antityphoid vaccination in June, 1914." Note the inference that unsuspecting Germany was caught unawares by the wicked French. Can it be that, at the battle of the Marne, the German host was suffering from the after-effects of this inoculation? We make a present of the explanation to the German Press Bureau. Referring to the English rifle bullet, the author describes it as "the most cruel munition of war found among the European armies." The admission to the pages of a reputable periodical of such an absurd statement as this, written by an unqualified student, is a glaring example of editorial laxity.

Gunshot Injuries of Bones. (Oxford War Primers. Under the General Editorship of Lieut.-Col. D'Arcy Power, R.A.M.C.) By Ernest W. Hey Groves, M.D., M.S. Small 8vo. Illustrated. 1915. London: Henry Frowde and Hodder & Stoughton. 3s. 6d. net.

This primer is a welcome and opportune addition to the literature which the great war has inspired. Captain Hey Groves has on other occasions published his views on the physiology and treatment of fractures, and the present volume is an endeavour to focus his experience in dealing with the complicated injuries which surround us. He limits the work to a practical discussion of the severe gunshot injuries of the long bones, with a special view to establishing a satisfactory system for their treatment.

The author has no doubt as to the function of the periosteum. He considers it to be a mere capsule of connective tissue, which serves the purpose of a limiting membrane. He says: "Periosteum never forms bone, though it greatly favours bone growth," and on this fact is based the endless discussion on the subject of osteogenesis. Bone contains all the tissues necessary for osteogenesis apart from the periosteum, but this structure assists osteogenesis, inasmuch as it acts as an intermediary between the osteoblast on the one hand and the vascular system on the other.

Captain Groves, in dealing with the pathological side of bone injuries, considers that there are three chief factors which determine the nature of the tissue reaction to infection: (1) The nature and severity of the infection; (2) The vascular supply of the injured bone; and (3) The drainage.

He admits it is impossible to determine beforehand whether a septic fracture will heal well and quickly, or slowly and badly; yet we can often quite certainly determine by our treatment which this issue is to be. In view of the severe course which these injuries are at times apt to take, it would be encouraging to feel our possible ascendancy; but with the most complete fixation and free drainage, many surgeons know that oftentimes they must be content if they only succeed in advantageously influencing, without really controlling, the changes that occur. The author is convinced that massive necrosis very rarely occurs in gunshot injuries unless the bones be exposed to operative procedures such as drilling into the marrow cavity, and in this opinion most surgeons of experience will agree. He summarizes what he considers the fundamental points in the treatment of gunshot bone injuries by the statement that septic comminuted fractures repair easily, and that when infection has ceased to become aggressive, repair is more rapid than in simple bone injuries; he states, furthermore, that immobilization tends to rapid repair, and that this tendency actually causes deformity if treatment is delayed; and that non-union will result from faulty treatment—such as the removal of living bits of bone, or by operations which interfere with the blood-supply and spread infection.

We must entirely agree with the author when he condemns the surgeon who excuses the neglect of a fracture, such as that of the femur, because he thinks the sepsis of more importance than the fracture. This excuse could only obtain if the treatment of the wound and the treatment of the fracture were essentially opposed to one another. Instead of being antagonistic, the reverse is true: immobility of the limb is an important factor in hastening the disappearance of sepsis. We are not, however, prepared to agree with him when he says that gunshot fractures allowed to heal in positions of great deformity are necessarily evidence of ignorance or neglect, although such a conclusion is often forced upon us.

In dealing with the subject of non-union, Captain Groves emphasizes the fact that non-union is not a common complication of gunshot fractures, but when it does occur, it is most often in the humerus and in transverse fractures of the tibia. He ascribes this to two chief causes: (1) The inclusion of soft parts between the fragments, especially in fracture of the humerus. He advises extension for the prevention of this. In this connection it is well to warn the surgeon that extension of the arm should be adopted with the greatest circumspection, as in civil life we know how likely it is to produce non-union. (2) In non-union of the tibia, the cause is ascribed to defective callus production. In the case of flail limb, the dangerous practice of removing large pieces of loose bone is held responsible. In fractures about joints, on the contrary, the removal of loose pieces is advocated, in order to avoid bony interference with mobility.

When the author deals with the general principles of treatment, we will heartily agree with his statement that if we are to save shattered limbs, it is necessary to provide free drainage, to remove septic foreign bodies, and to keep the main parts of the injured bone in correct position. It is also obvious that any appliance should be of such a character as to allow of easy access to the wound; that the main fragments of the bone must be placed in correct position as regards alinement and length; that during the evacuation of pus and the healing of the limb the fixation of the bone should be uninterrupted; and that the uninjured parts must be maintained in health and functional usefulness. When the author, however, comes to deal with the practical application of these principles, differences of opinion must arise as to the value of respective appliances. For instance when plaster-of-Paris is referred to as "probably the best of the immobilization methods," and the statement is made that with experience and the incorporation of pieces of metal so as to leave the wound free "it can give quite good results," the surgeon may be tempted to employ it, in spite of the author's statement that it "fails us in the early stages of the most severe cases." Of all the methods in use, the long Liston splint included, plaster-of-Paris is that against which the young surgeon should be most rigorously warned. The weight and pulley which the author recommends is very far short of ideal. With every movement of the body it becomes an intermittent pull, and is a sure incentive to muscular revolt; and, at a period such as this (when a fracture should be put up in such a way at first as to need no modification during transport), it has but a limited application. The ideal splint is that which is self-contained, where extension—whatever its form, continuous or retentive—can be maintained with ease, and which need not be altered even on arrival at home. These requisites are secured by the use of the Thomas knee splint, which, for reasons by no means convincing, Captain Groves condemns. A Thomas splint, properly applied, will overcome pronounced shortening without any of the disadvantages which the author fears. The modification which is figured in the text cannot allow of adequate extension, and is not suited to the conditions which prevail at the front—stretcher work, the swinging of M.A.C. cars, and the rolling of hospital ships. This is equally true of Hodgen's cradle splint, which the author considers the best of text-book patterns; and of his own fixed wire cradle splint, which requires fracture boards, a weight and pulley, and sandbags—an impossible combination for transport. The author admits that his method of extensioen will not suffice to overcome overlapping in certain cases—such as those in which treatment has been delayed—and for such he recommends the use of transfixion screw-clamps.

Captain Groves does excellent service in pointing out the dangers of plating bones. In effect, he tells us that it means extensive opening up of soft tissues to infection; that it involves boring of holes into the medullary cavity, each of which infects the marrow; that it often communicates and causes extensive necrosis; and that it may result in the loss of the limb. The author has learned from many surgeons who have received plated cases at home from the front, that the results have been uniformly disastrous, and this statement will be endorsed by very many.

The principles of treatment advocated are thus summarized: thorough initial wound cleansing and drainage; immobilization without harmful interference with blood-supply; adequate extension in the correct direction; semiflexion of the joints; free access to wound; early movements of the joints.

The section on bone-grafting is interesting and clear. The conditions needed for success are: an absence of sepsis; the firm and close fixation of the graft to a living bone; abundant vascularity of the bone bed; and an outside periosteal covering of the graft. Autogenous grafts are more reliable than homogenous. The best sources are the tibia, fibula, and rib. The graft is to be securely fixed to its bed of bone by being driven tightly into the medullary cavity, and by making transverse drill holes through both graft and bed and suturing by wire firmly twisted, or by bolting the graft to its bed.

The author has written a very interesting if somewhat controversial handbook, which is well worthy of study. The illustrations are good, and the opinions expressed are lucid and emphatic, if not always unchallengeable.